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NORTHERN HEMISPHERE MONTHLY MEAN 500-MILLIBAR AND 1000-500-MILLIBAR THICKNESS CHARTS AND SOME DERIVED STATISTICS (1951-66)

BY

B. J. MOFFITT and R. A. S. RATCLIFFE, M.A.

LONDON: HER MAJESTY'S STATIONERY OFFICE

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NORTHERN HEMISPHERE MONTHLY MEAN 500-MILLIBAR AND 1000–500-MILLIBAR THICKNESS CHARTS AND SOME DERIVED STATISTICS (1951–66)

1 – INTRODUCTION

Means and extremes of 1000–500-mb thickness for each month in the period 1946–51 have been available in another Meteorological Office publication[1]* for a number of years. However, the data on which that publication was based were sparse and, over some parts of the northern hemisphere, entirely absent, so that it was considered worth while to prepare a revised and extended publication including data from as much as possible of the northern hemisphere for a longer and thus more statistically representative period of years.

The World Meteorological Organization (WMO) recommends that a period over which averages are taken should commence on the first year of a decade[2] and the first complete decade for which upper air data have been available for most of the northern hemisphere began in 1951. The period 1951–66 has also been used in the Meteorological Office as a reference period from which anomalies of various quantities have been obtained in support of long-range forecasting research and also in operational long-range forecasting. Hence it was decided to use the data for 1951–66 to prepare the new charts of:

(a) 500-mb monthly mean contours for each month of the year (12).

(b) 1000–500-mb monthly mean thickness isopleths for each month of the year (12).

(c) Extreme values of 1000–500-mb thickness for each month. Of these charts, 12 give the highest values of 1000–500-mb thickness and 12 give the lowest values of 1000–500-mb thickness, at grid points over much of the northern hemisphere (24).

(d) Mid-season (January, April, July and October) charts showing the variation of standard deviation of 500-mb height (4).

(e) Mid-season (January, April, July and October) charts showing the variation of standard deviation of 1000–500-mb thickness (4).

(f) Mid-season (January, April, July and October) charts indicating the areas of positive and negative skewness in the distribution of 500-mb height (4).

(g) Mid-season (January, April, July and October) charts indicating the areas of positive and negative skewness in the distribution of 1000–500-mb thickness (4).

In addition, monthly extreme maxima and minima of 500-mb height at each grid point were produced but are not included here in map form because of their probable limited use. However, as these values might be of use for the quality control of computerized data they have been included in tabular form in Part IV.

It is hoped that the charts of extreme thickness may be of use not only in quality control of computerized data but also in day-to-day forecasting as an aid to assessing the probable development of extreme situations (either warm or cold). Such situations are always difficult to predict even a short time ahead but they are very important from the user point of view. The charts of monthly average thickness and of standard deviation, taken in conjunction, may also aid the forecaster in assessing the intensity of cold or warm outbreaks which are not expected to break records. These charts provide a coherent picture for the 16-year period covered by the observations. However, this period is rather short for the estimation of statistics such as standard deviations and coefficients of skewness, and readers should bear this in mind when relating them to statistics for other periods.

*The superscript figures refer to the Bibliography on page 60.

PART I – DISCUSSION OF THE CHARTS

2 – 500-MILLIBAR MONTHLY MEAN CONTOUR CHARTS

These charts are represented by Figures 1(a)–(l). The winter charts (December, January and February) are very similar with a 2-wave pattern in high latitudes and a pattern with 3 or 4 waves near 50°N. There is a tendency for bipolarity in the circumpolar vortex with centres usually near the Canadian Archipelago and north-east Siberia. Flow is strong, with well-marked troughs and ridges. The Canadian trough is sharp and positioned near 70/75°W at 50°N and the main Siberian trough is also sharp and fairly constant in position near 140°E at 50°N. The European trough is less well defined but shows as a definite feature around 30°E. A weak ridge at about 10°W at 50°N is also detectable.

As the year advances, the flow generally becomes weaker with the polar vortex closer to the pole and winds generally more westerly. The Canadian trough begins to move eastwards during March and from then until October is situated between 55° and 65°W at 50°N before gradually sharpening and moving westwards in late autumn. The Siberian trough remains near 140°E until May when it progresses to mid Pacific to remain between 170°W and 170°E from May until October, returning abruptly to its winter position in November. The European trough becomes ill defined after March with a tendency to take up a position over or just west of the Greenwich meridian, especially in late summer and early autumn, before reappearing near 30°E in December. The weak ridge in the winter at about 10°W moves over the British Isles in March to May but then disappears in the summer. It is discernible again near 10°E in September and October before retreating to 10°W again in December.

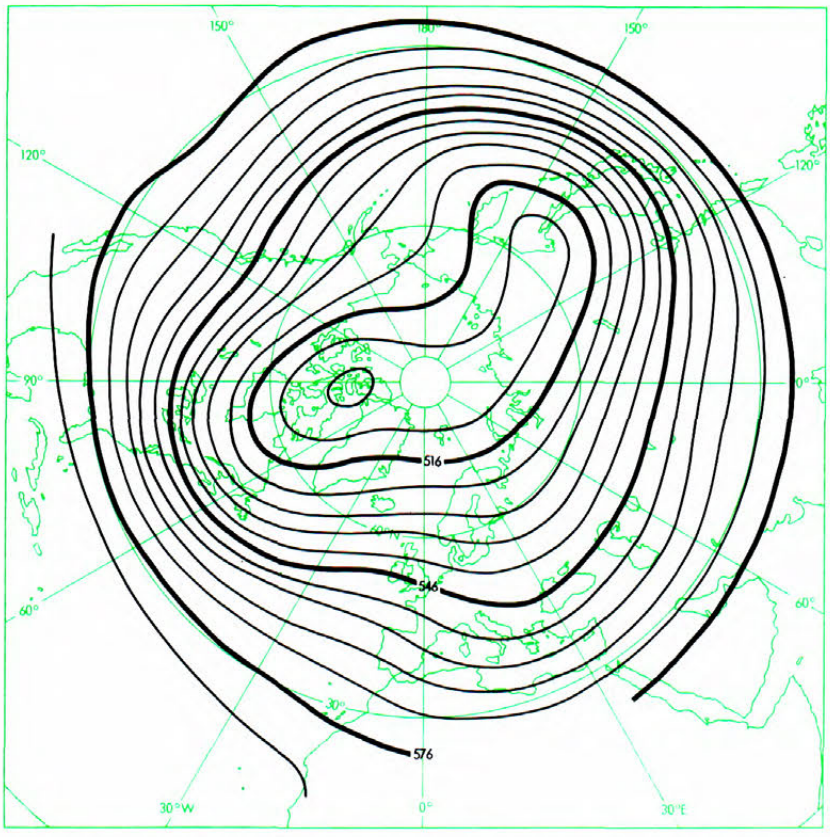

FIGURE 1(a). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR JANUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

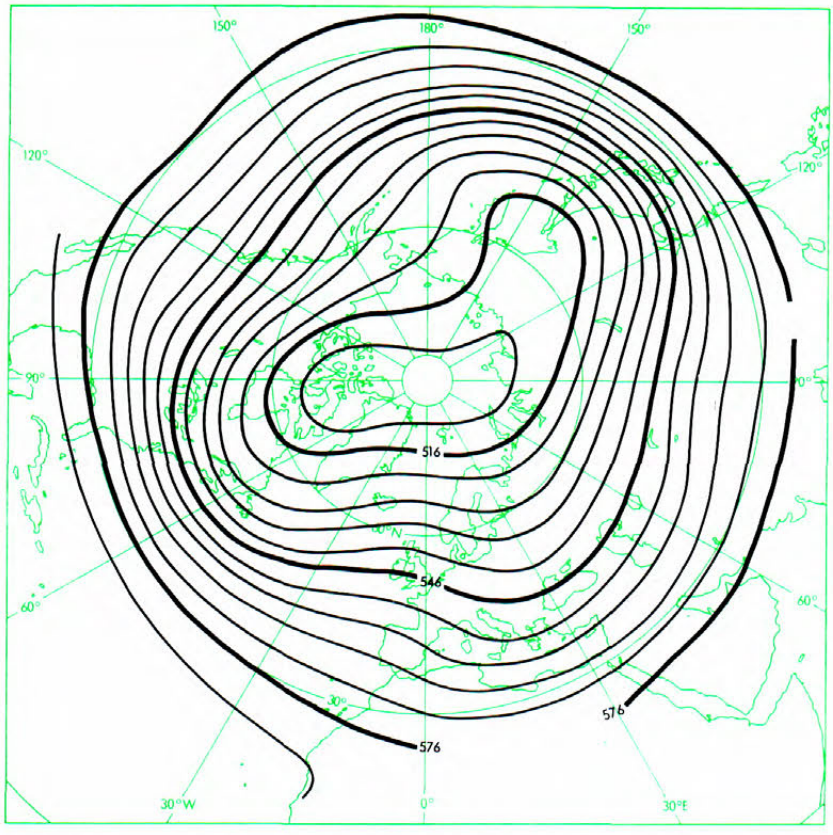

FIGURE 1(b). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR FEBRUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

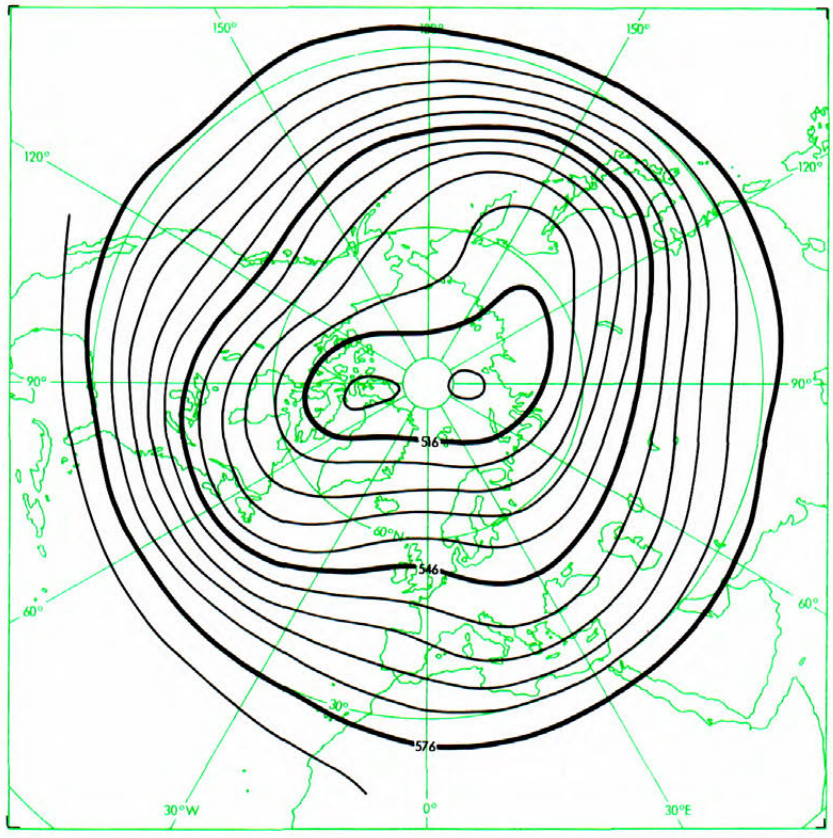

FIGURE 1(c). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR MARCH 1951–66
Isopleths are at intervals of 6 geopotential decametres

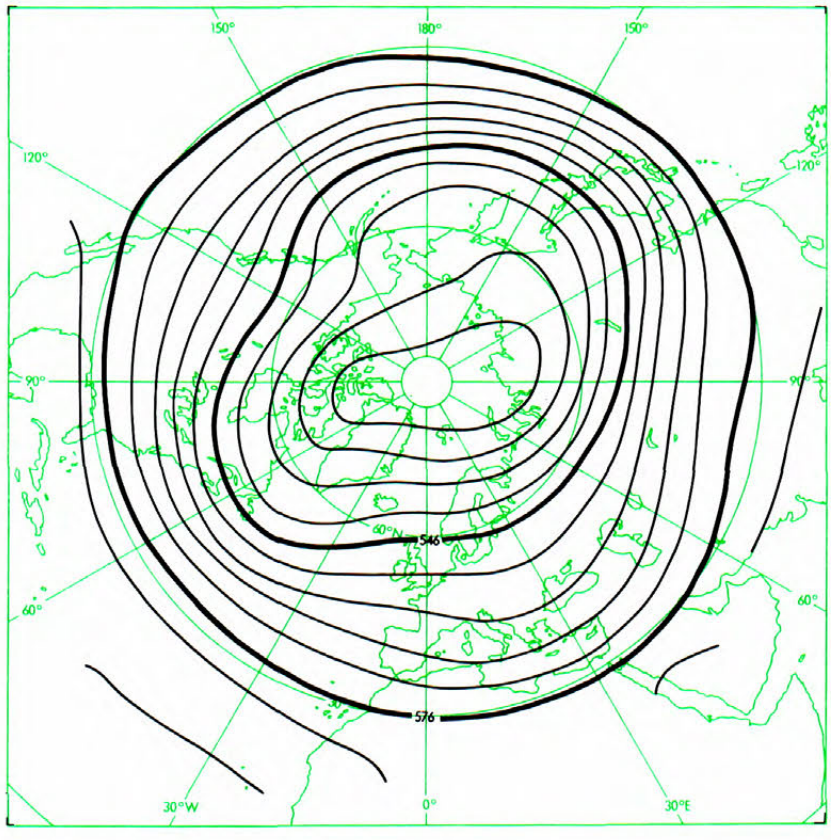

FIGURE 1(d). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR APRIL 1951–66
Isopleths are at intervals of 6 geopotential decametres

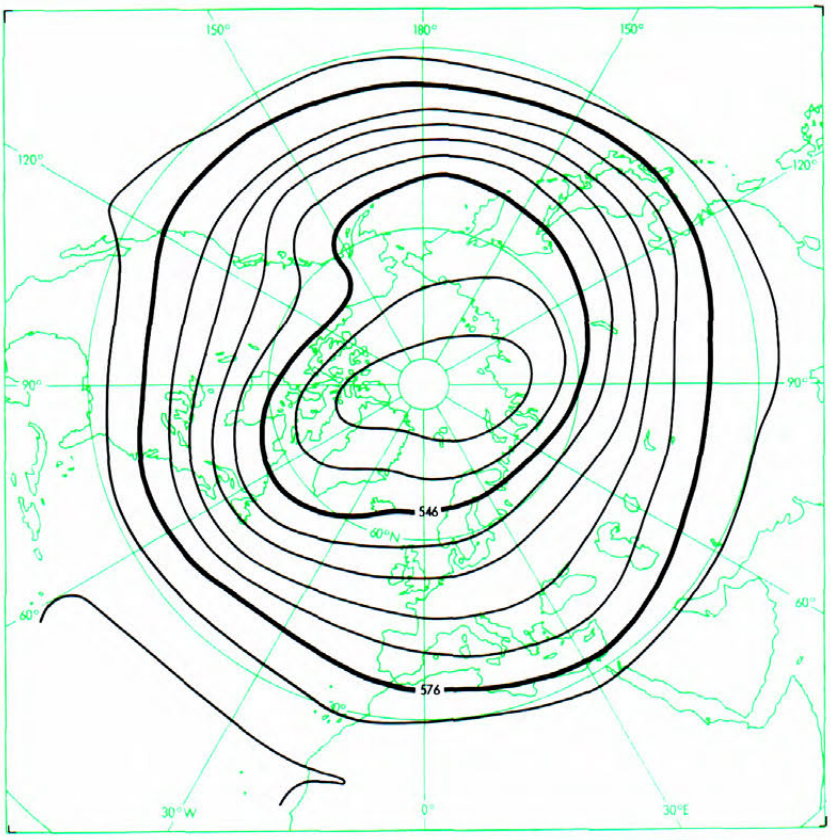

FIGURE 1(e). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR MAY 1951–66
Isopleths are at intervals of 6 geopotential decametres

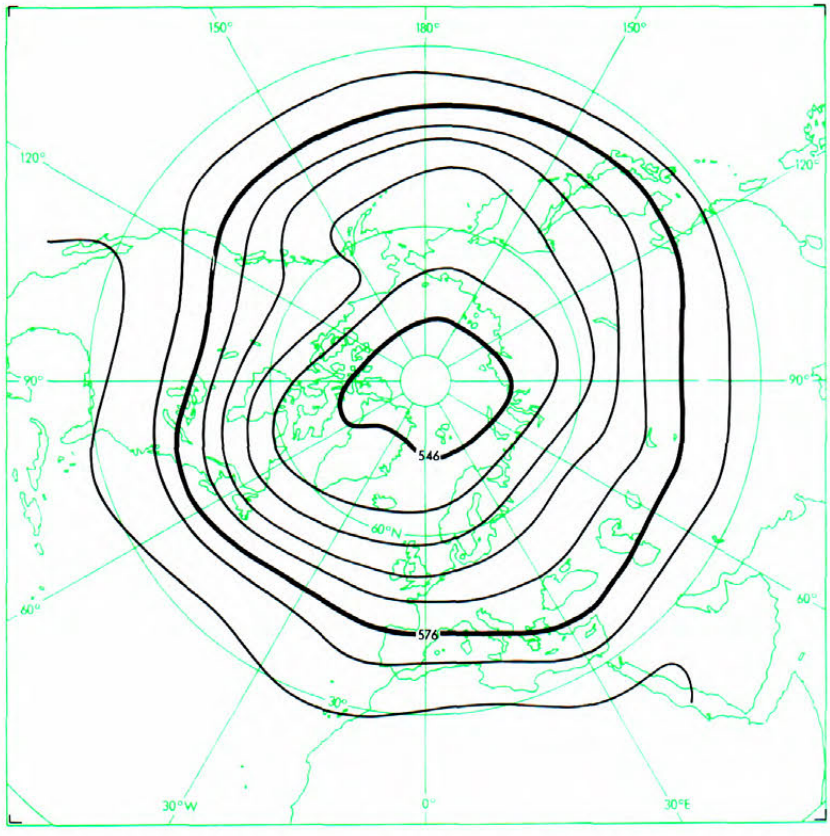

FIGURE 1(f). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR JUNE 1951–66
Isopleths are at intervals of 6 geopotential decametres

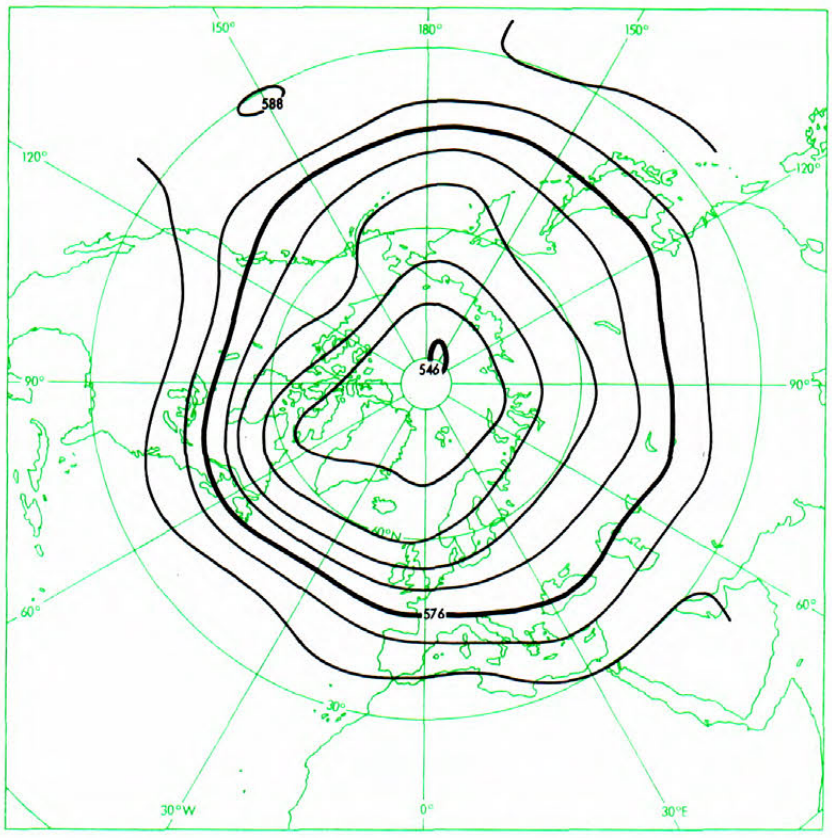

FIGURE 1(g). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR JULY 1951–66
Isopleths are at intervals of 6 geopotential decametres

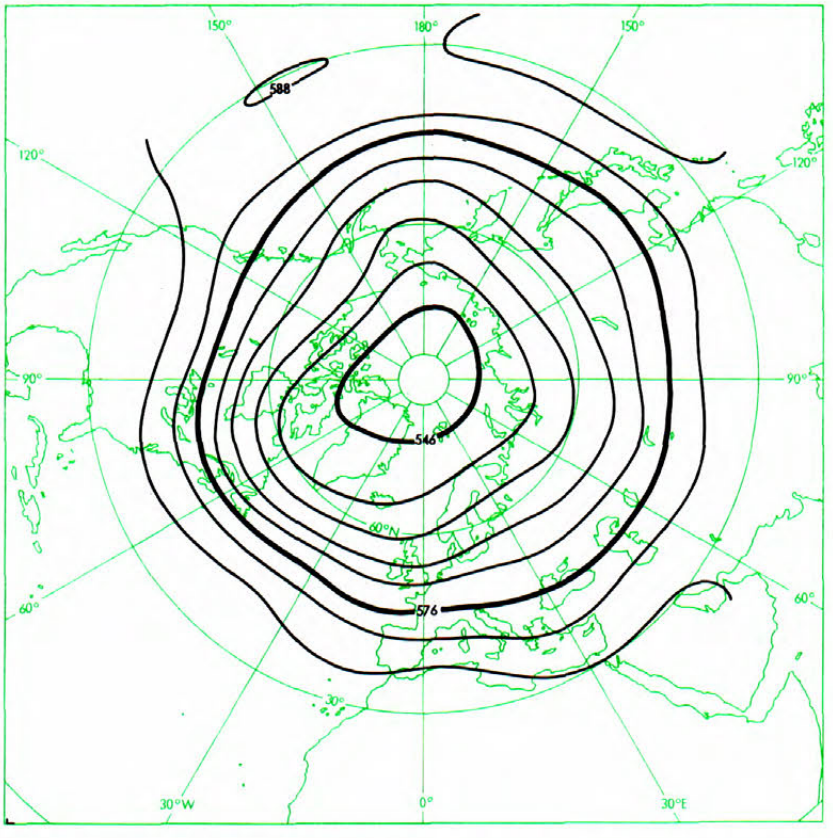

FIGURE 1(h). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR AUGUST 1951–66
Isopleths are at intervals of 6 geopotential decametres

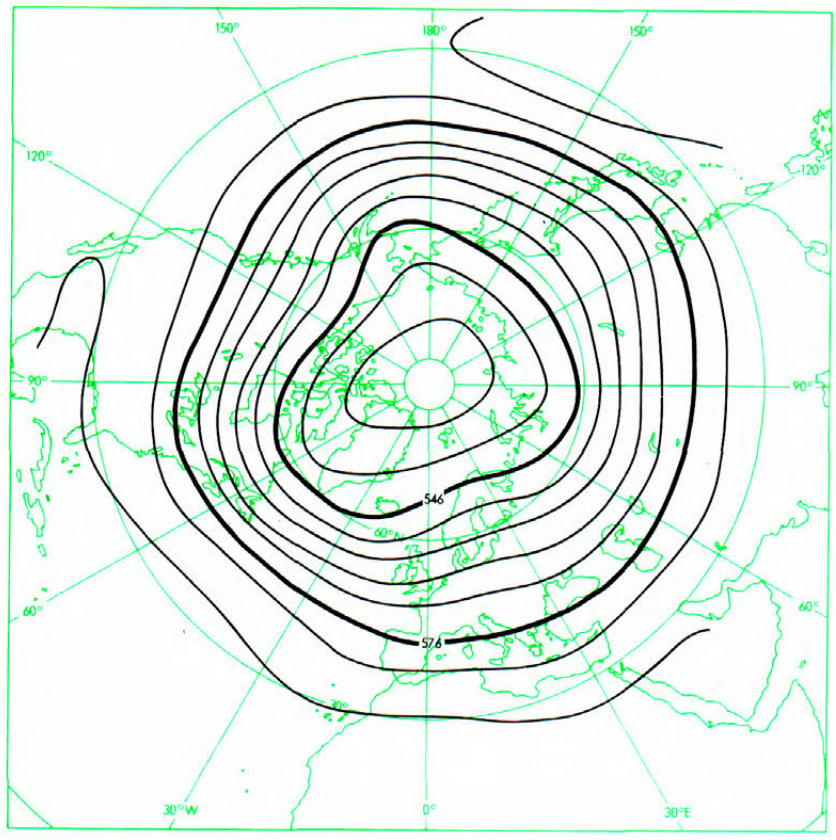

FIGURE 1(i). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR SEPTEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

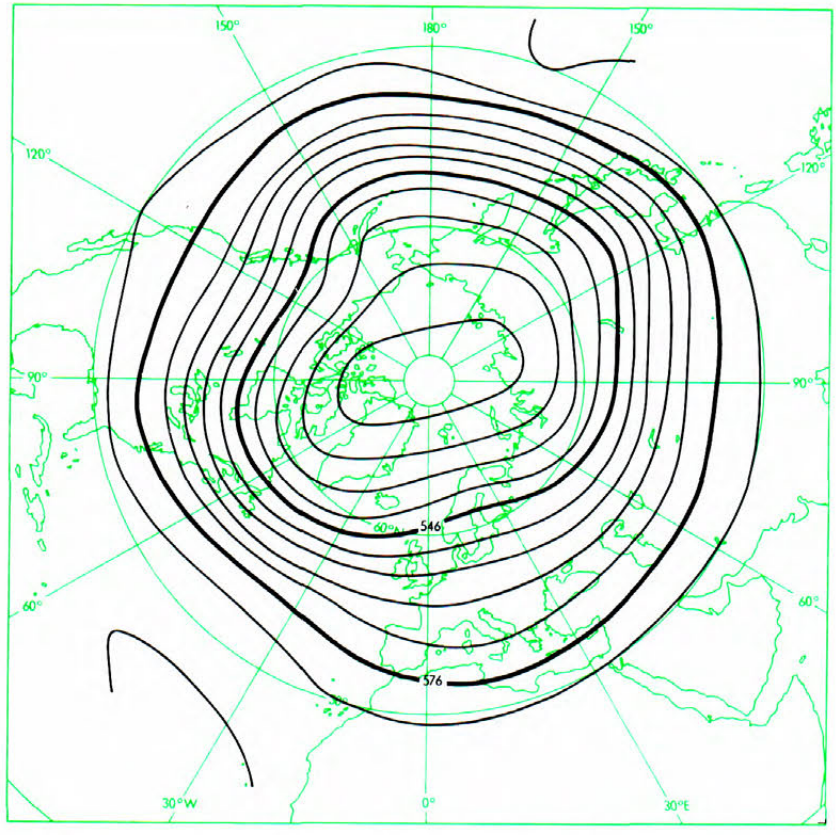

FIGURE 1(j). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR OCTOBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

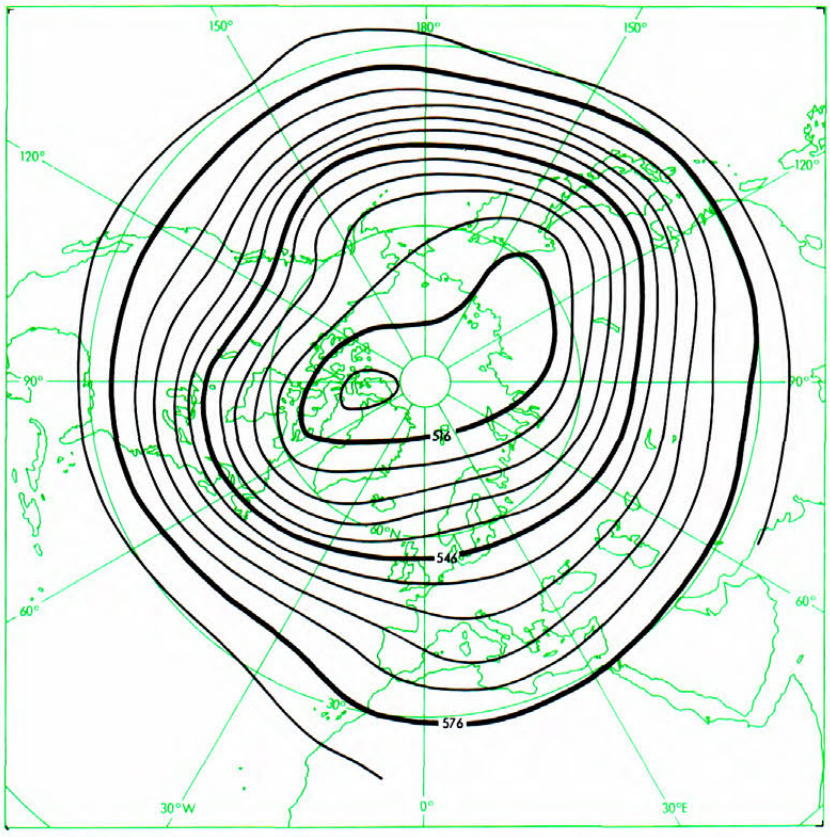

FIGURE 1(k). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR NOVEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

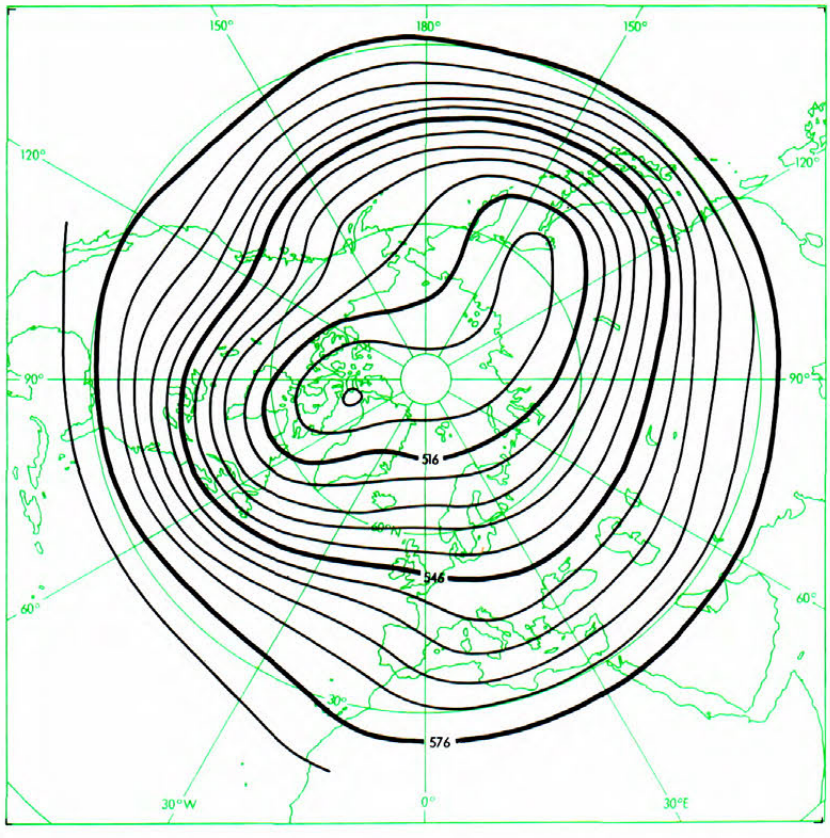

FIGURE 1(l). MONTHLY MEAN 500-MILLIBAR CONTOURS FOR DECEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

3–1000–500-MILLIBAR MONTHLY MEAN THICKNESS CHARTS

The behaviour of the main features on the thickness charts (Figures 2(a)–(1)) around the year is similar to that of the corresponding 500-mb features. The established winter positions of the Canadian and Siberian troughs are near 80°W and 125°E at 50°N with marked bipolarity in high latitudes. Normally there are vortices over the Canadian Archipelago and in Siberia near 60°N 125°E. The European trough is not well defined in winter but there is usually a ridge near 15°W. In summer, as thickness gradients between high and low latitudes are weaker than in winter, the patterns become weaker and more zonal with the Canadian trough in general being less well defined and near 60°W. The main trough in the thickness lines is now over the central Pacific with a poorly defined trough near or just west of the Greenwich meridian from May to September. The Siberian trough takes up its winter position in October but the Canadian one does not become so well established until December.

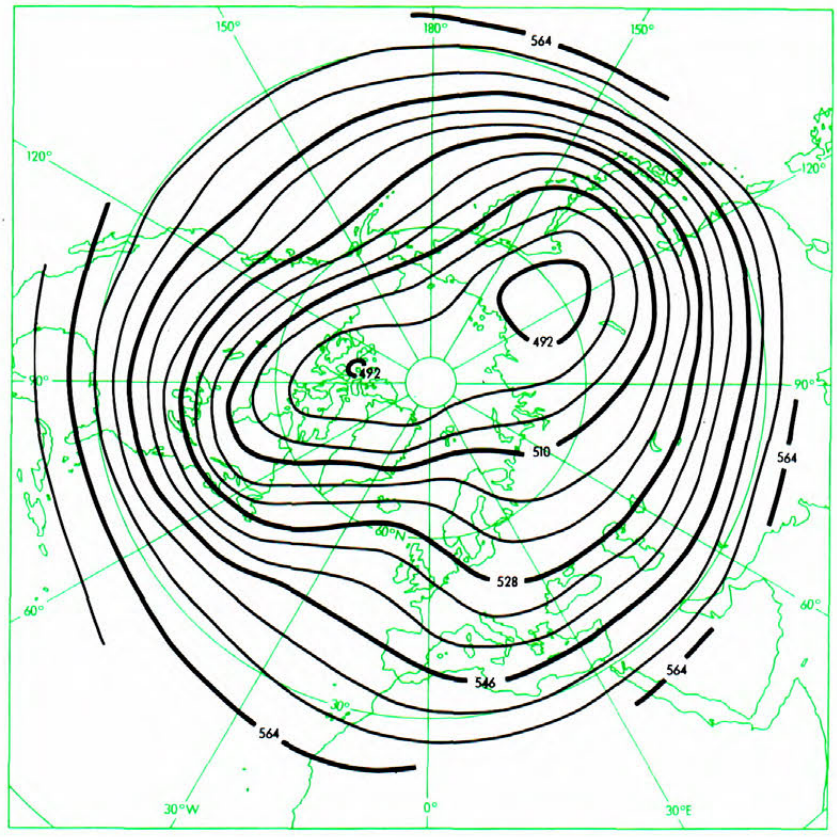

FIGURE 2(a). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR JANUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

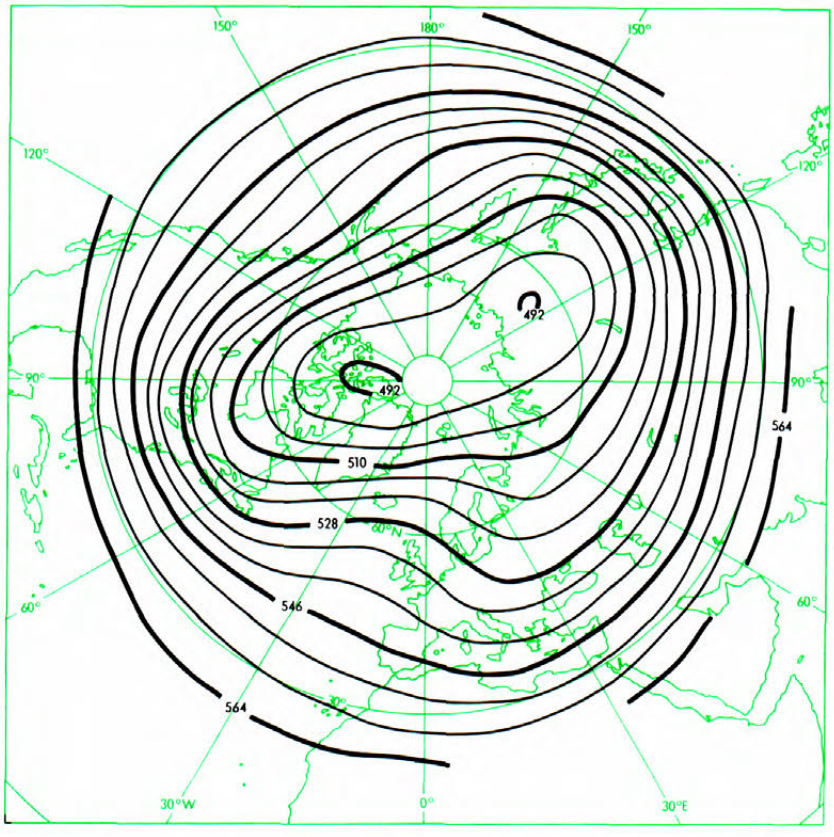

FIGURE 2(b). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR FEBRUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

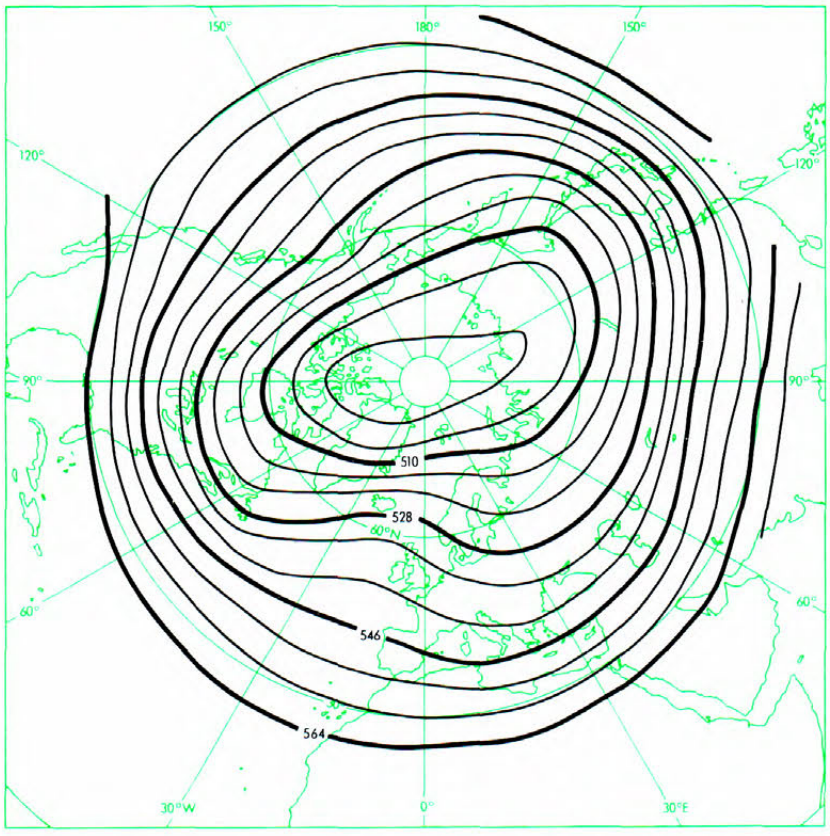

FIGURE 2(c). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR MARCH 1951–66
Isopleths are at intervals of 6 geopotential decametres

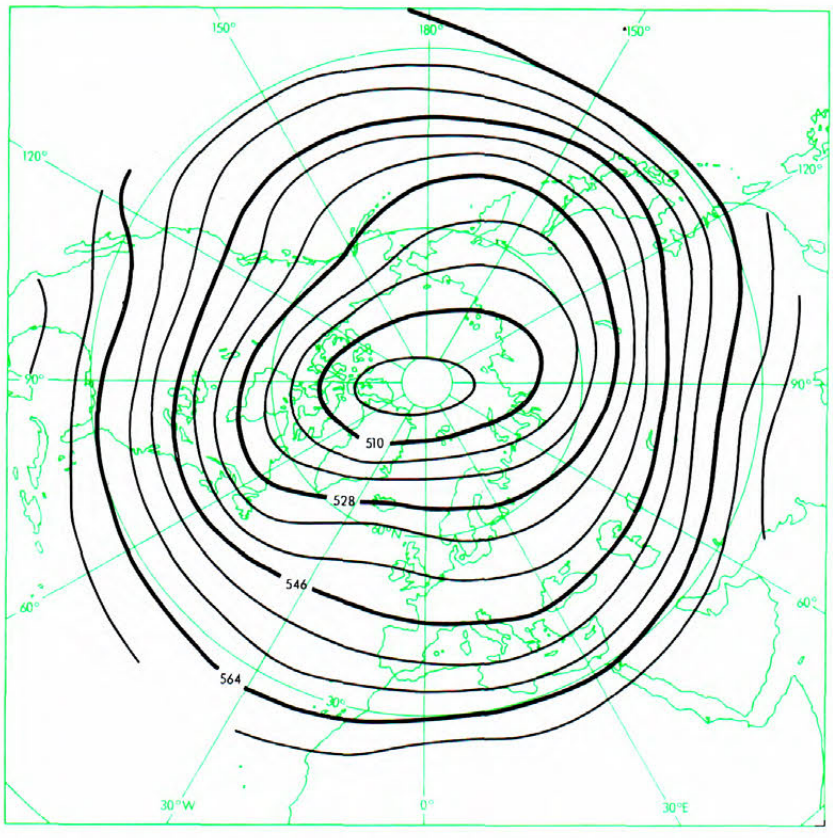

FIGURE 2(d). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR APRIL 1951–66
Isopleths are at intervals of 6 geopotential decametres

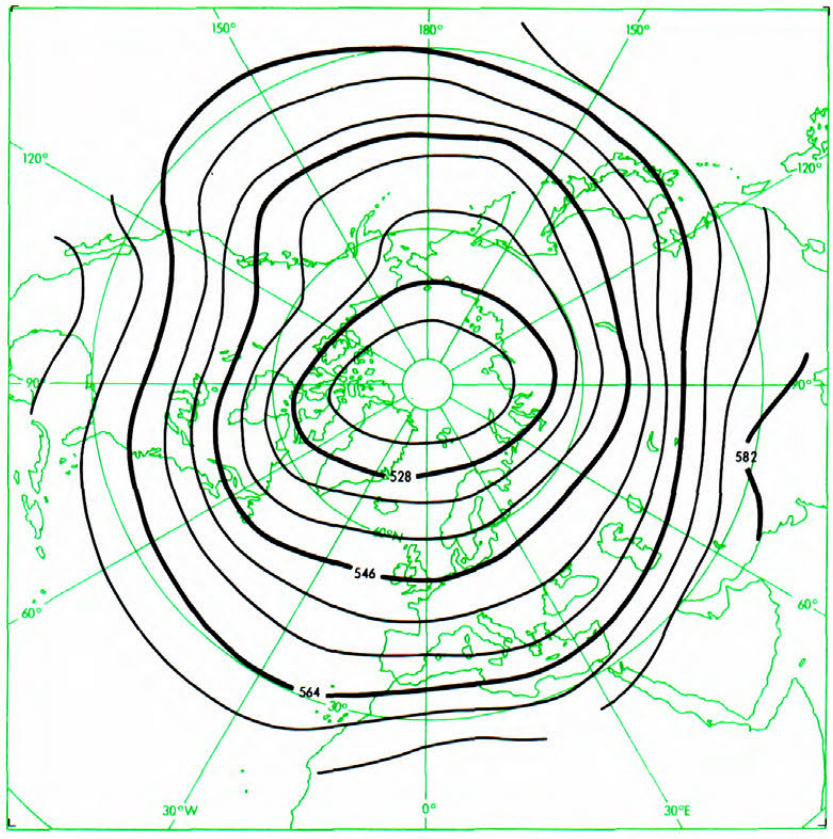

FIGURE 2(e). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR MAY 1951–66
Isopleths are at intervals of 6 geopotential decametres

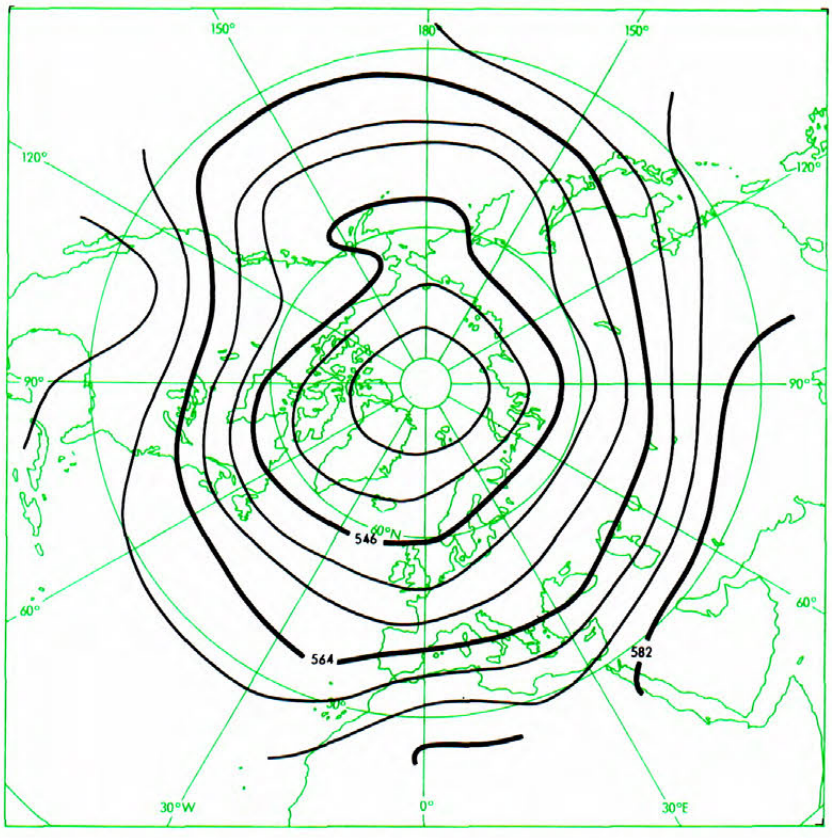

FIGURE 2(f). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR JUNE 1951–66
Isopleths are at intervals of 6 geopotential decametres

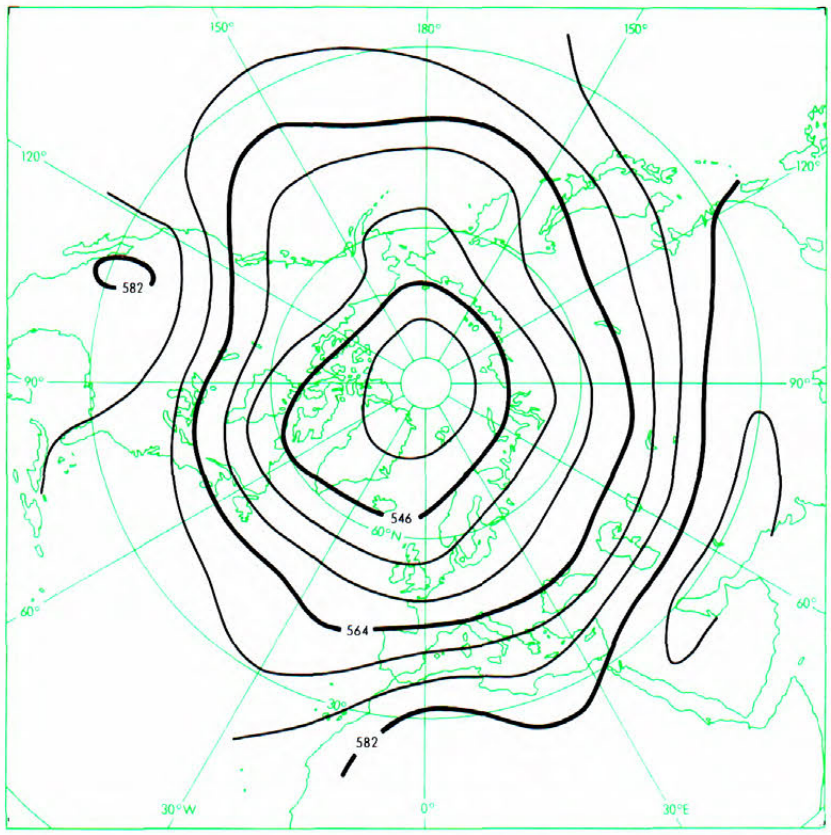

FIGURE 2(g). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR JULY 1951–66
Isopleths are at intervals of 6 geopotential decametres

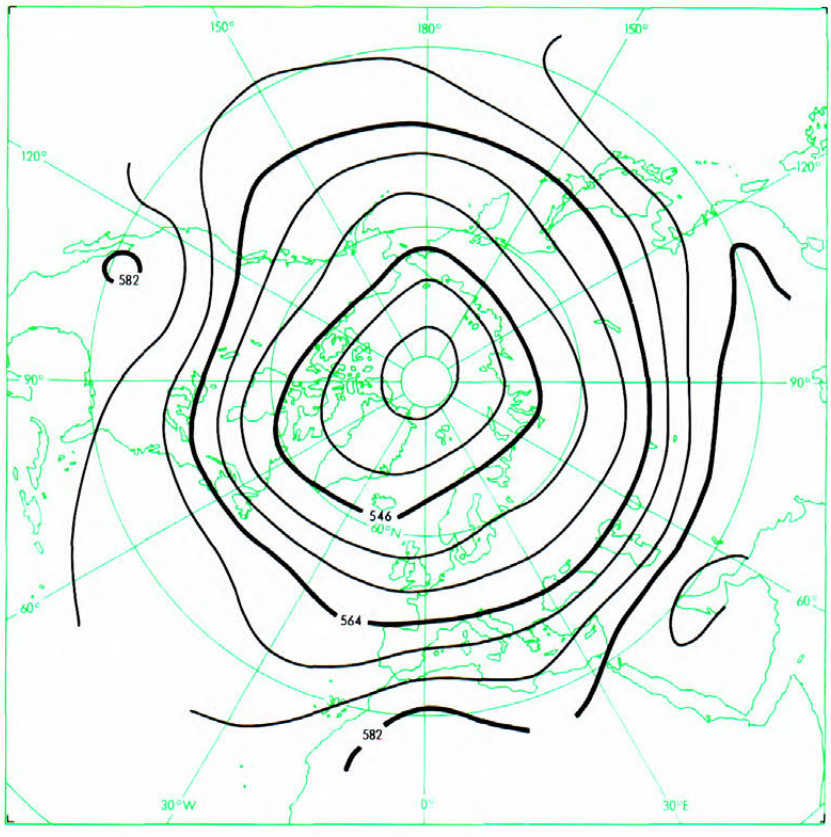

FIGURE 2(h). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR AUGUST 1951–66
Isopleths are at intervals of 6 geopotential decametres

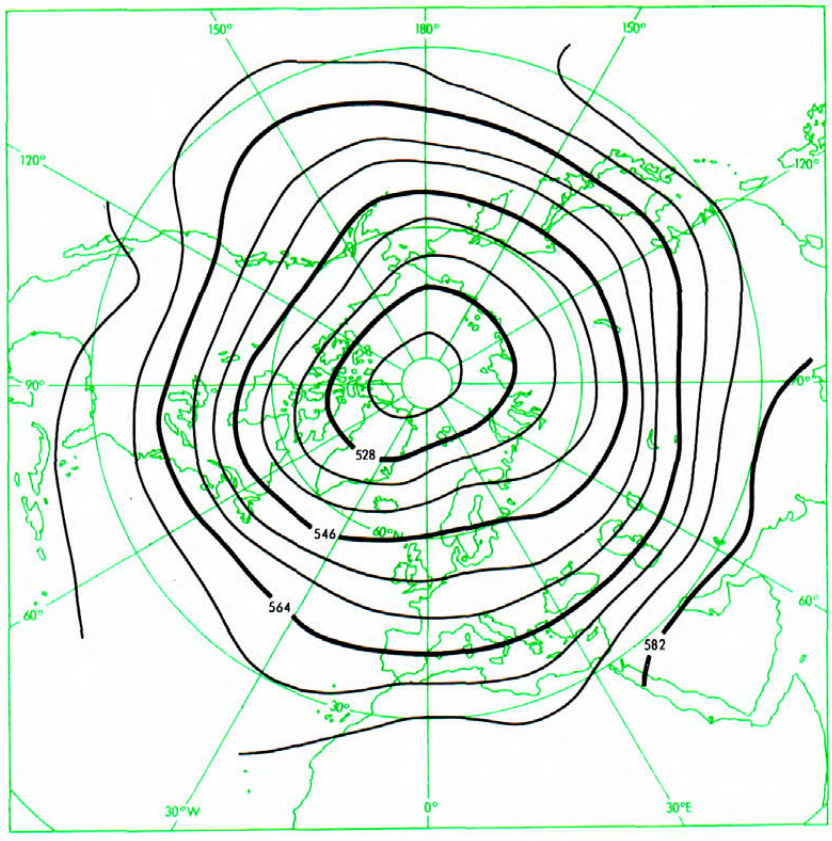

FIGURE 2(i). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR SEPTEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

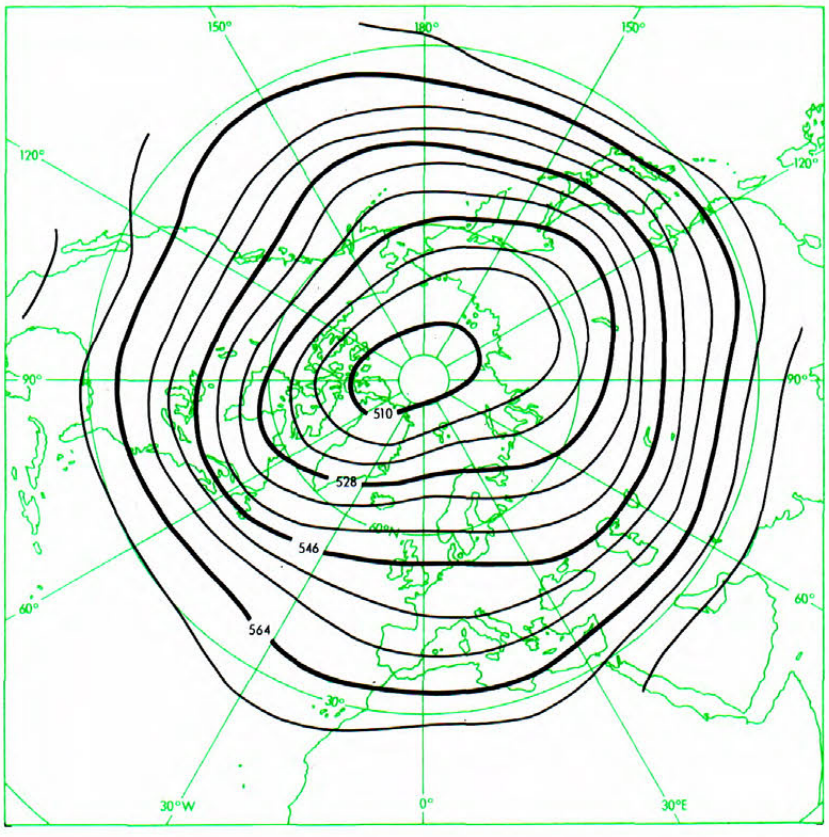

FIGURE 2(j). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR OCTOBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

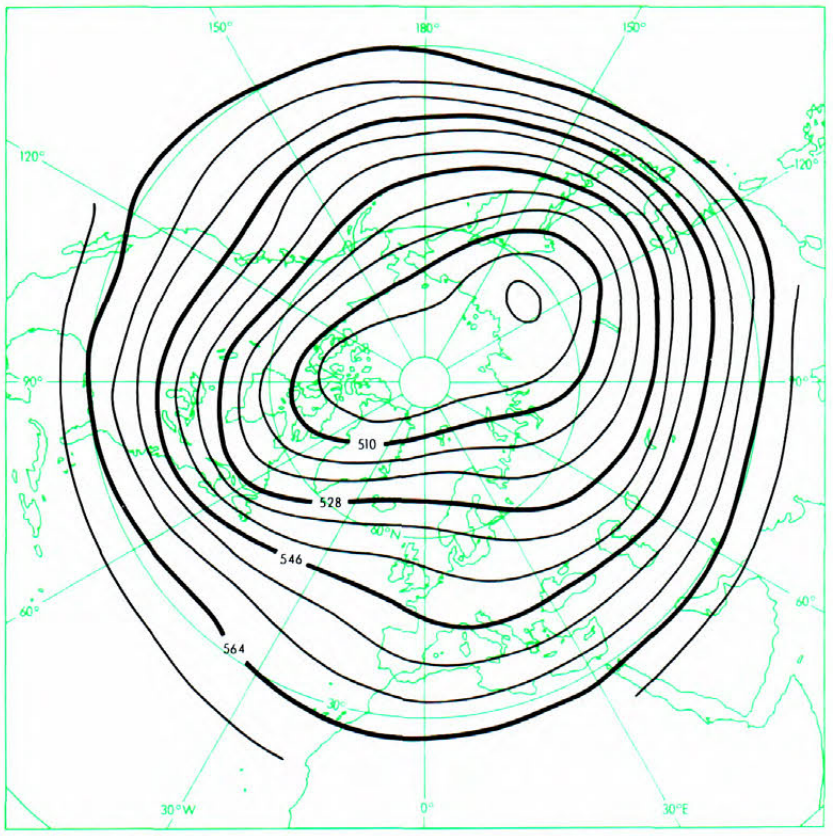

FIGURE 2(k). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR NOVEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

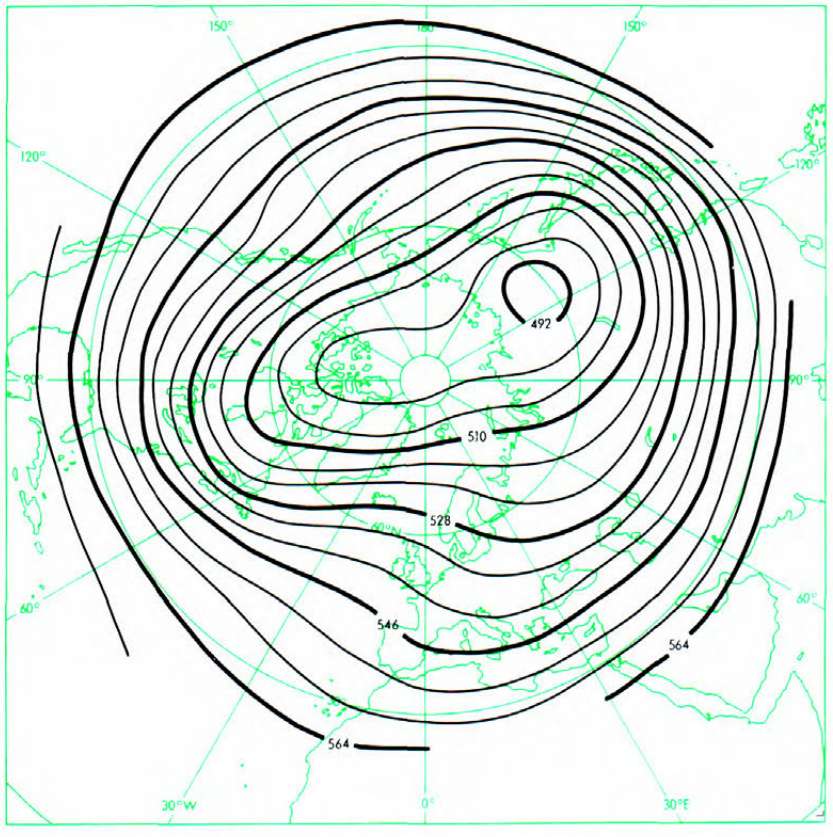

FIGURE 2(l). MONTHLY MEAN 1000–500-MILLIBAR THICKNESS FOR DECEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

4 – EXTREME MAXIMA AND MINIMA OF 1000–500-MILLIBAR THICKNESS

The main features on these charts (Figures 3(a)–(l) and 4(a)–(l)) reflect land/sea temperature differences. The highest maxima and minima in winter are usually found on the eastern sides of the main oceans or close to the western seaboards of the American and European continents, while the lowest maxima and minima are situated over eastern Canada and the eastern side of the Eurasian continent. In summer the opposite tends to be true with the lowest maxima and minima over the oceans and the highest maxima and minima over the continents. However, maximum thickness values over the western part of the American continent reach higher latitudes than those over the Eurasian mainland, the difference being as much as 10° of latitude in some months. The northward bulge of the maximum thickness lines also starts much earlier over America, being apparent over the south-west of the U.S.A. even in March.

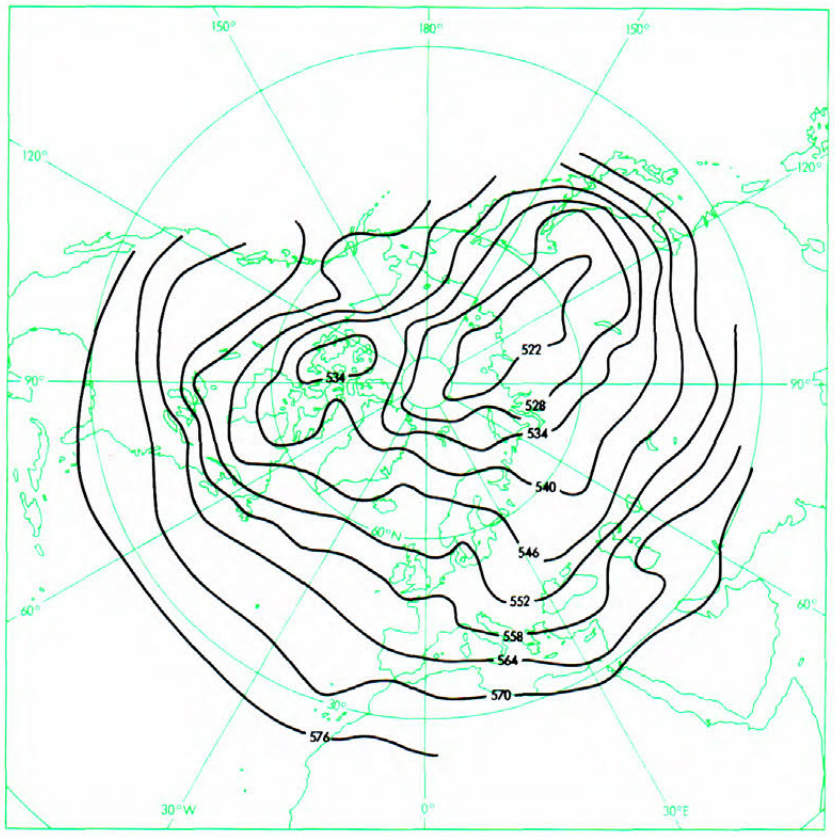

FIGURE 3(a). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR JANUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

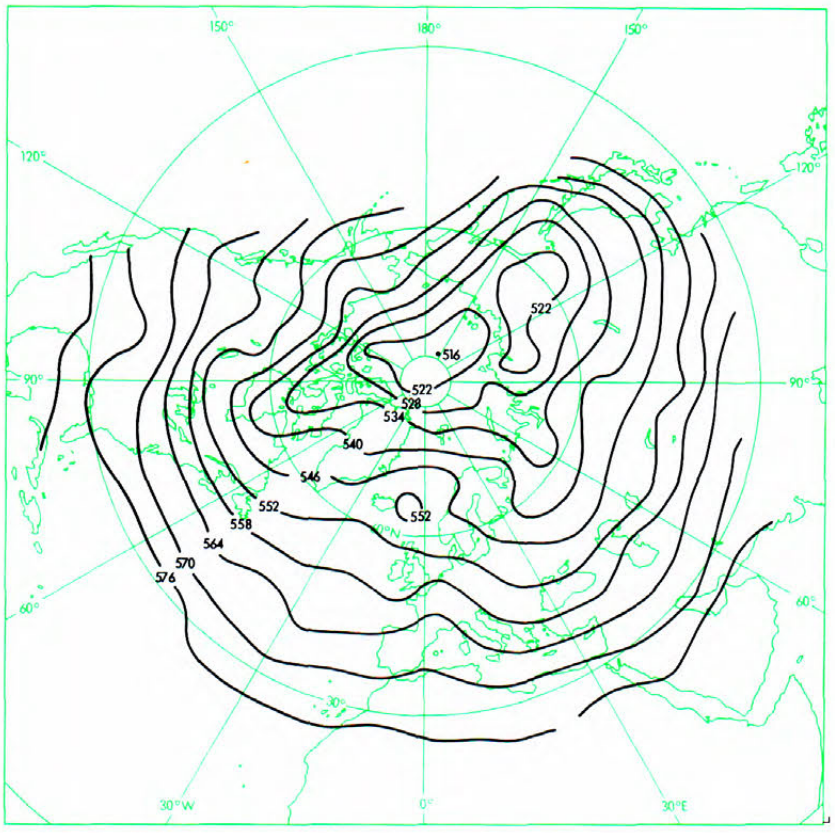

FIGURE 3(b). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR FEBRUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

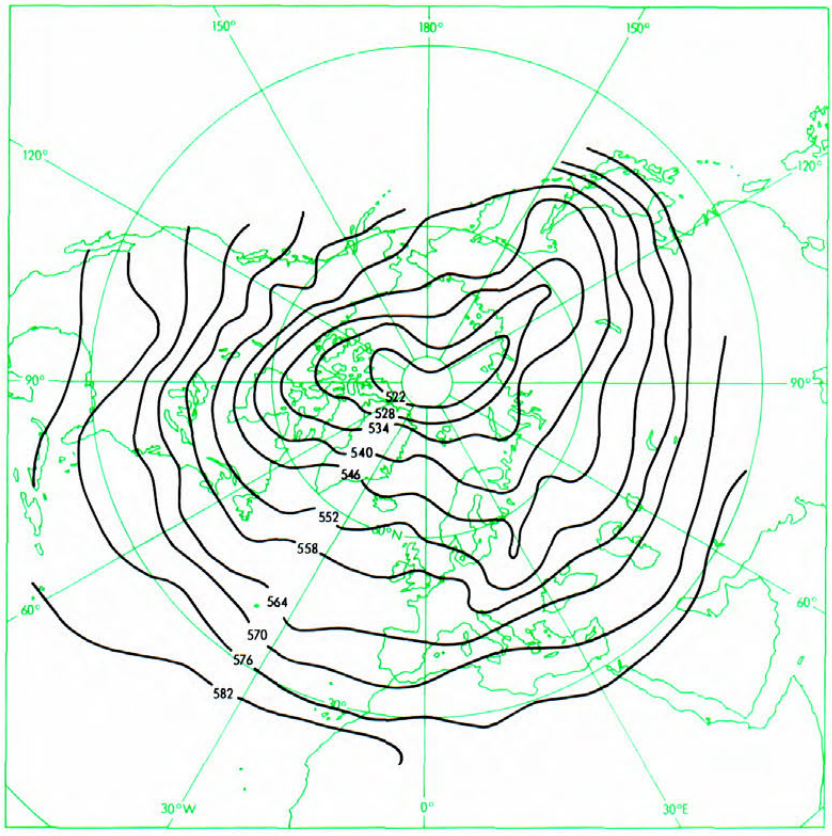

FIGURE 3(c). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR MARCH 1951–66
Isopleths are at intervals of 6 geopotential decametres

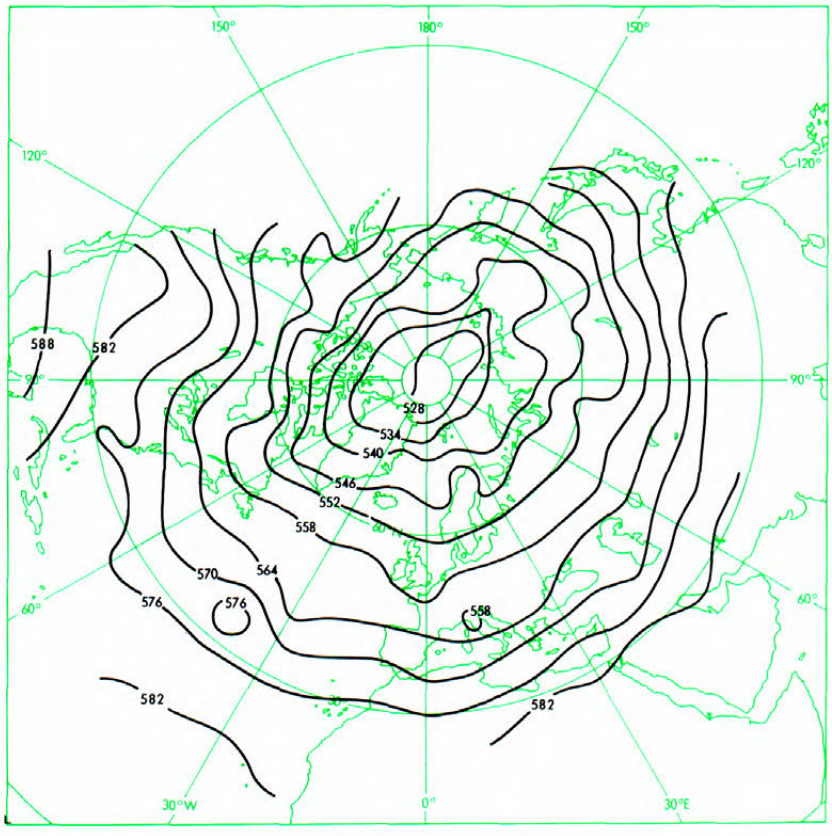

FIGURE 3(d). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR APRIL 1951–66
Isopleths are at intervals of 6 geopotential decametres

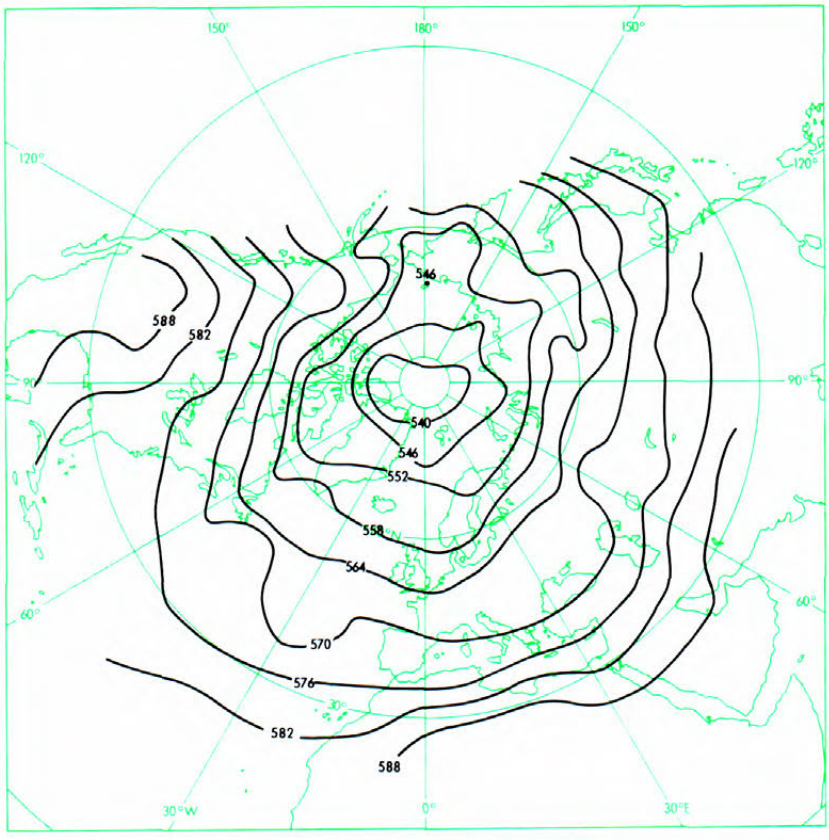

FIGURE 3(e). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR MAY 1951–66
Isopleths are at intervals of 6 geopotential decametres

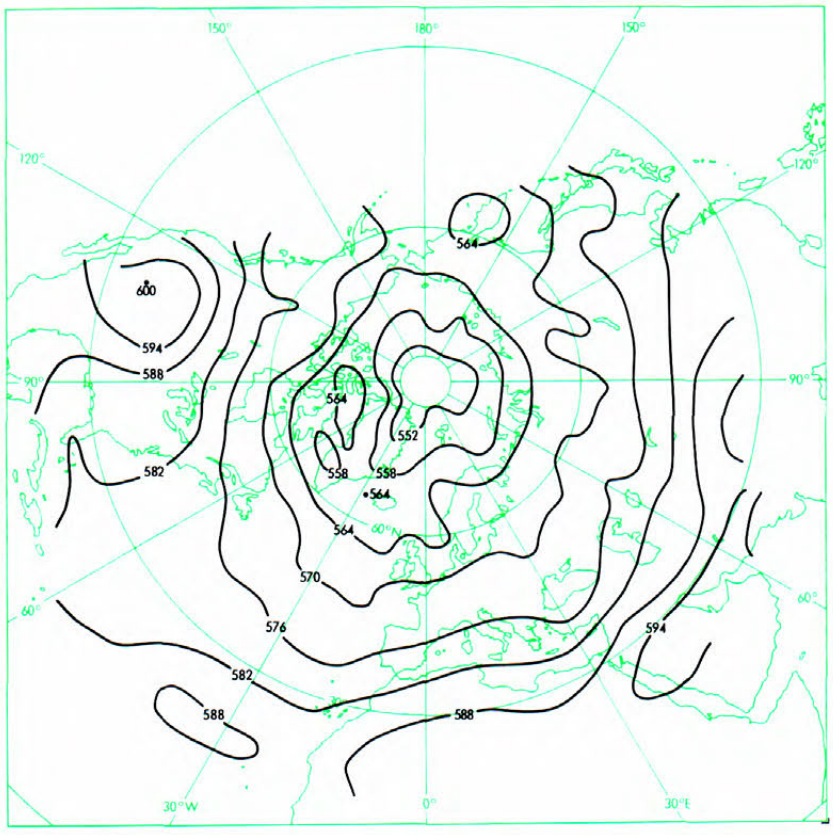

FIGURE 3(f). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR JUNE 1951–66
Isopleths are at intervals of 6 geopotential decametres

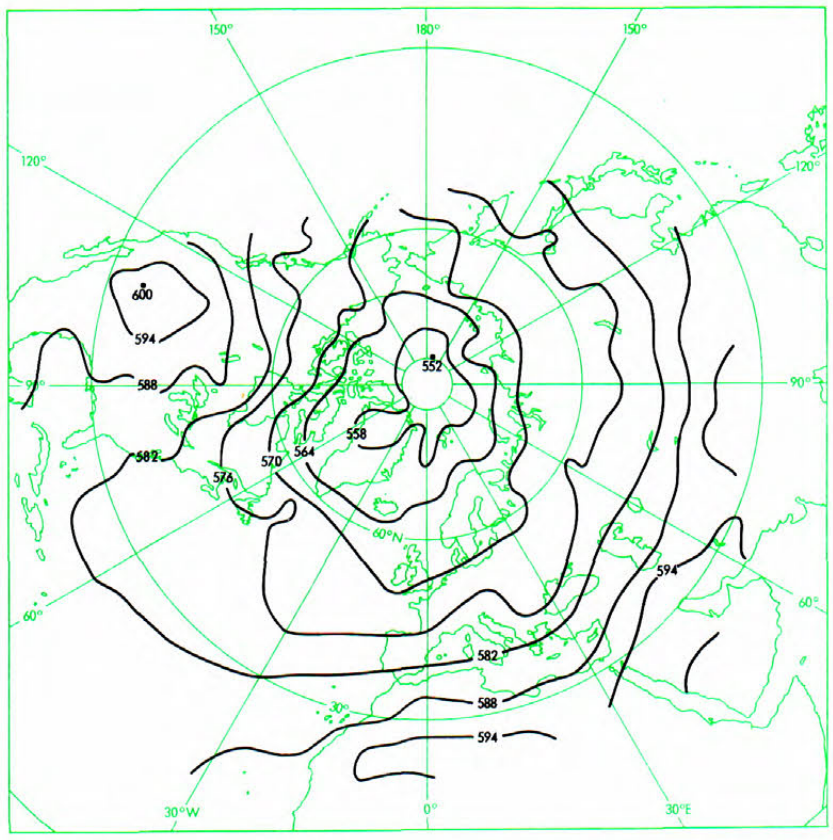

FIGURE 3(g). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR JULY 1951–66
Isopleths are at intervals of 6 geopotential decametres

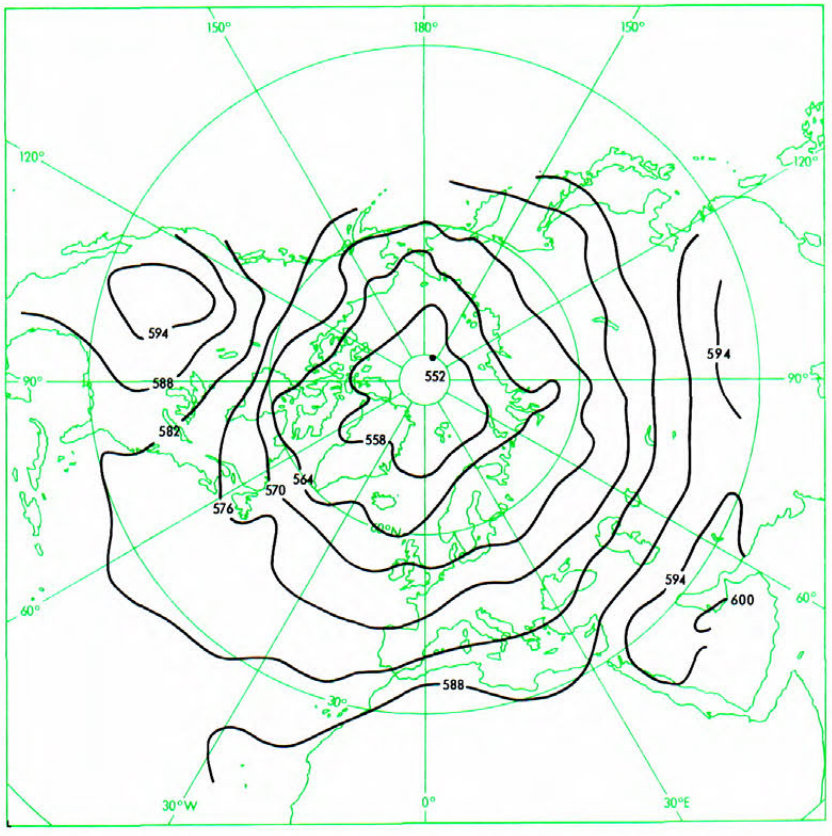

FIGURE 3(h). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR AUGUST 1951–66
Isopleths are at intervals of 6 geopotential decametres

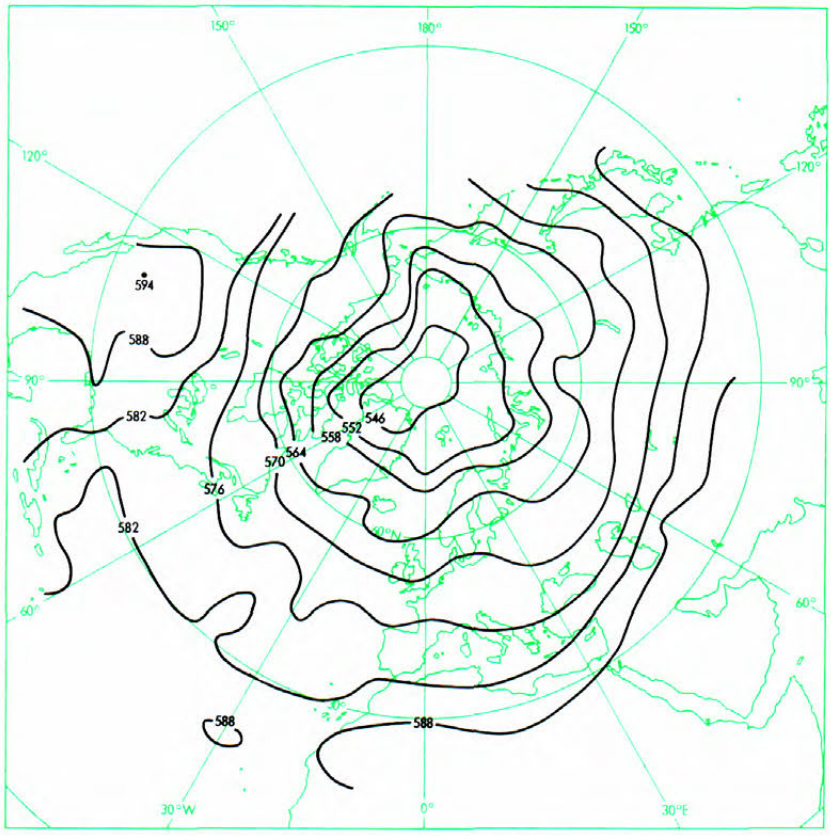

FIGURE 3(i). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR SEPTEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

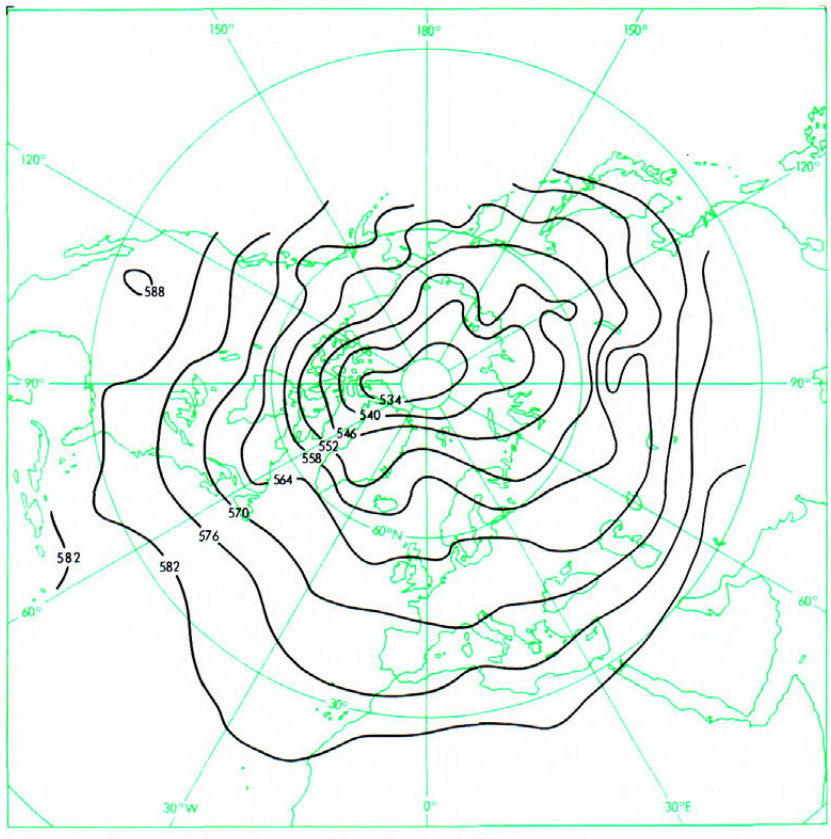

FIGURE 3(j). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR OCTOBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

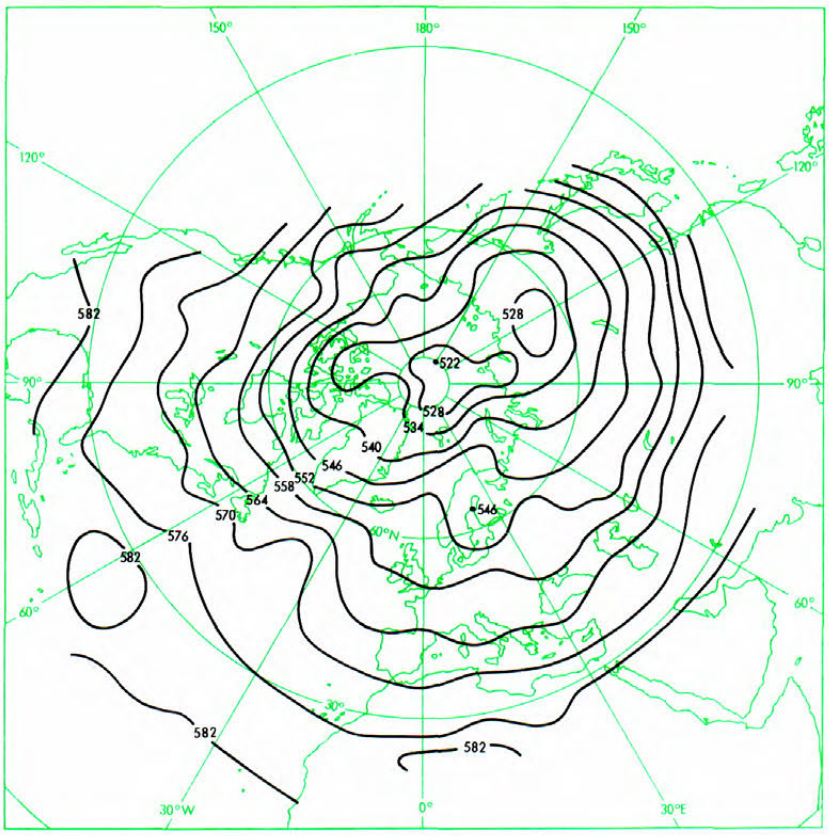

FIGURE 3(k). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR NOVEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

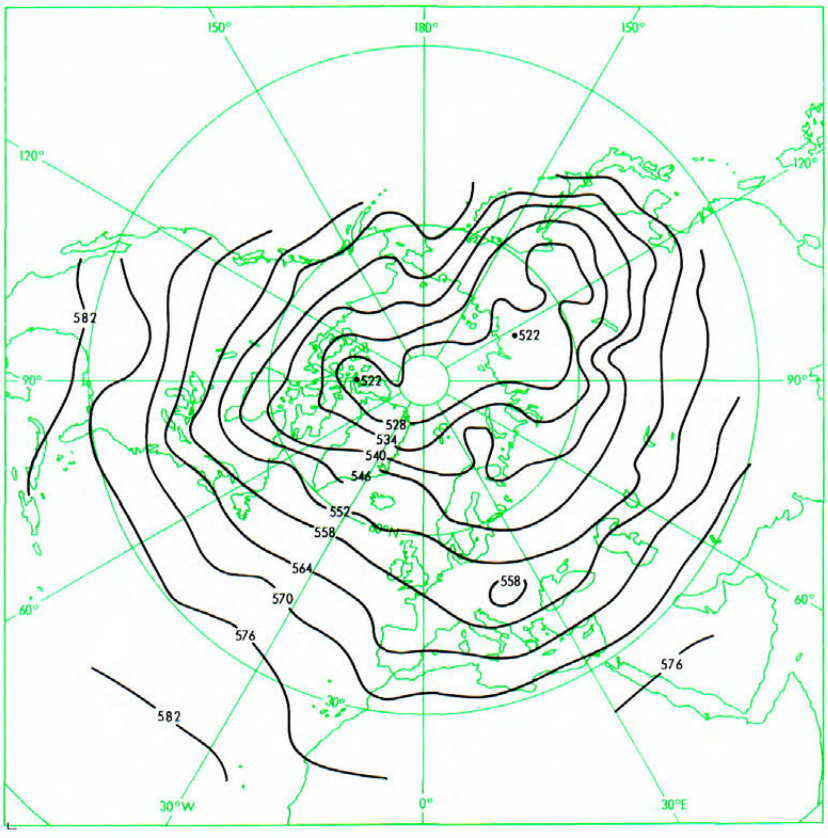

FIGURE 3(l). EXTREME DAILY MAXIMUM 1000–500-MILLIBAR THICKNESS FOR DECEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

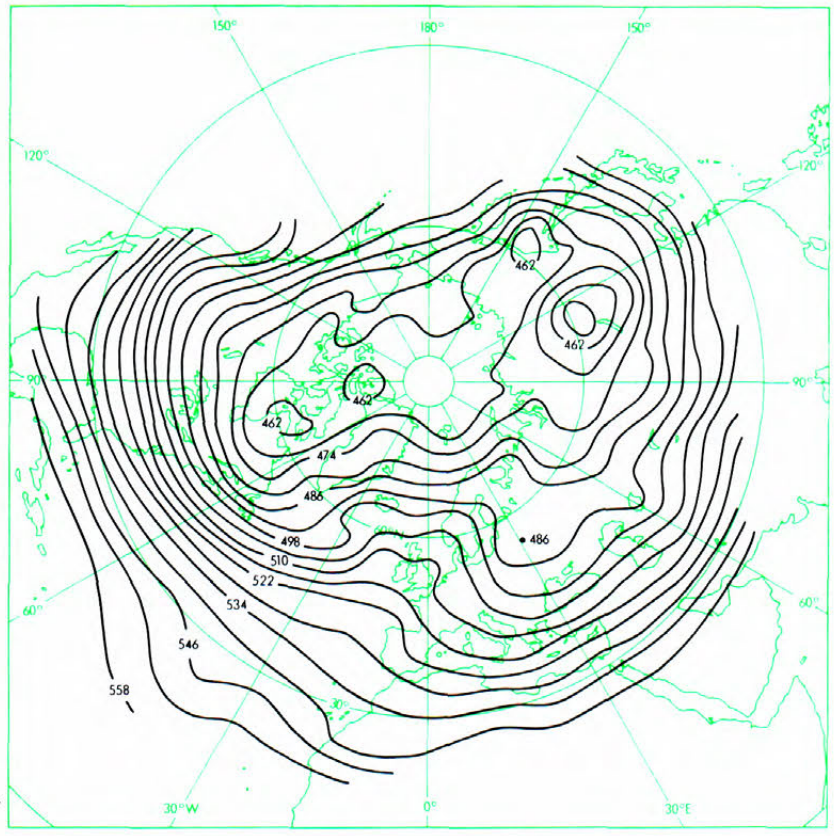

FIGURE 4(a). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR JANUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

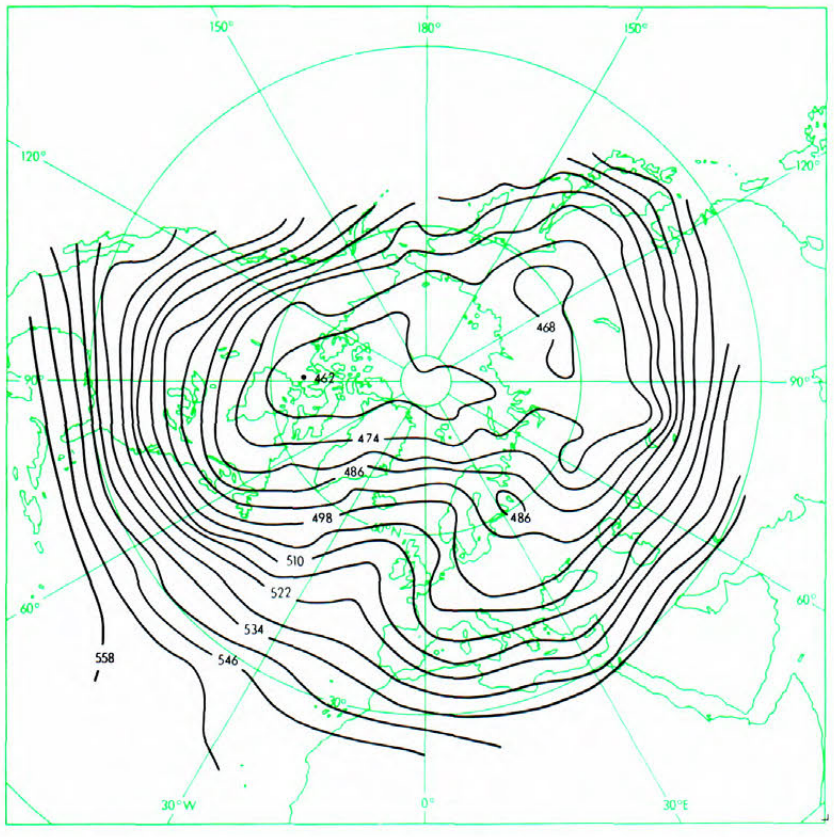

FIGURE 4(b). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR FEBRUARY 1951–66
Isopleths are at intervals of 6 geopotential decametres

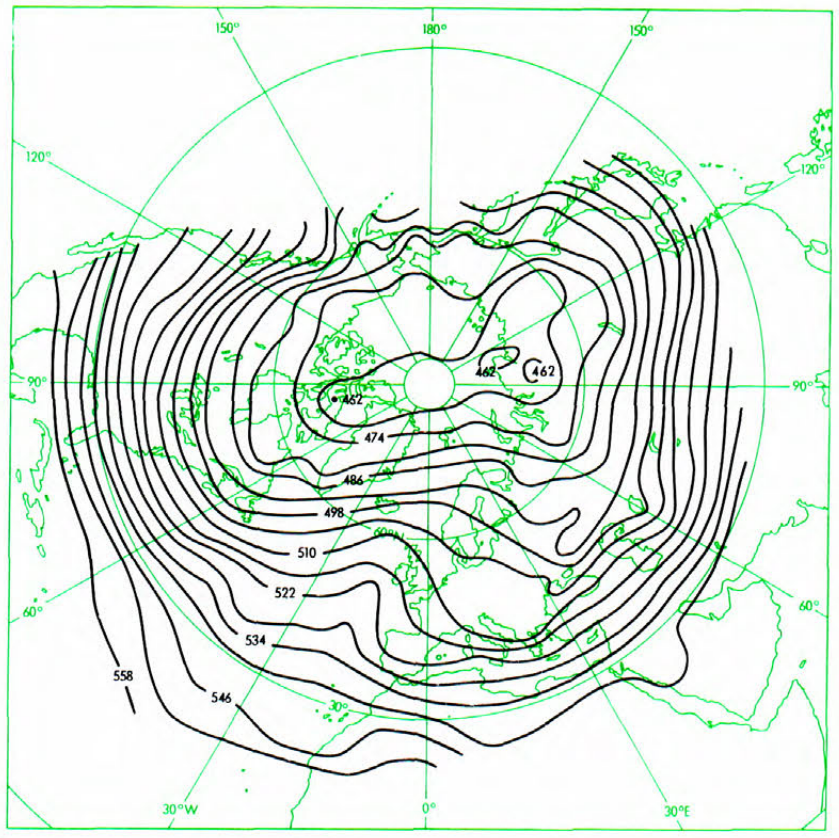

FIGURE 4(c). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR MARCH 1951–66
Isopleths are at intervals of 6 geopotential decametres

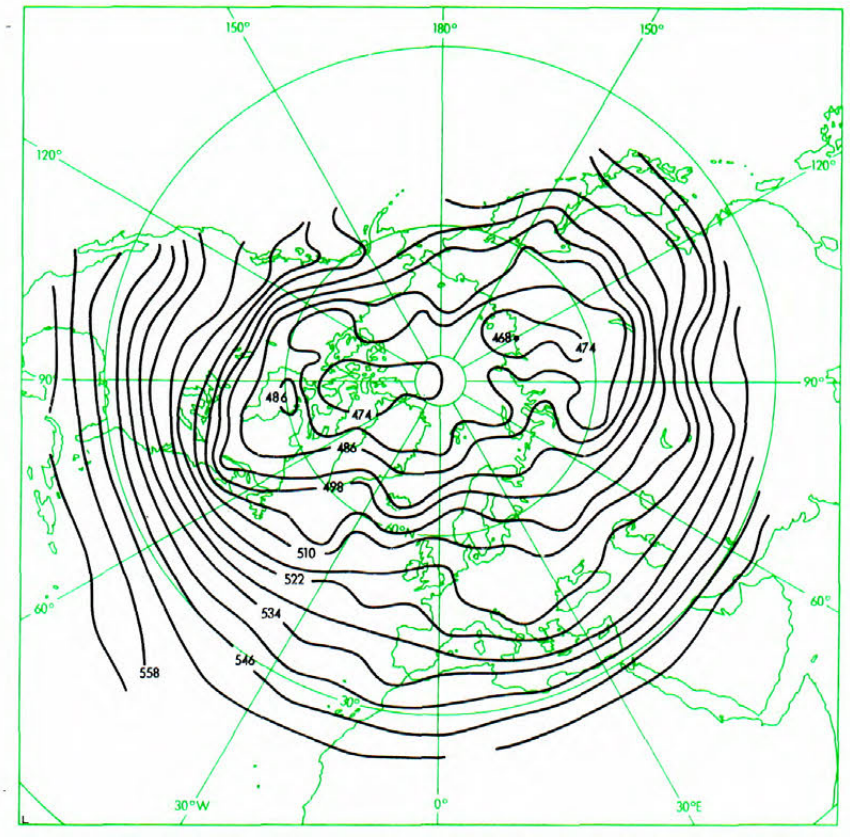

FIGURE 4(d). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR APRIL 1951–66
Isopleths are at intervals of 6 geopotential decametres

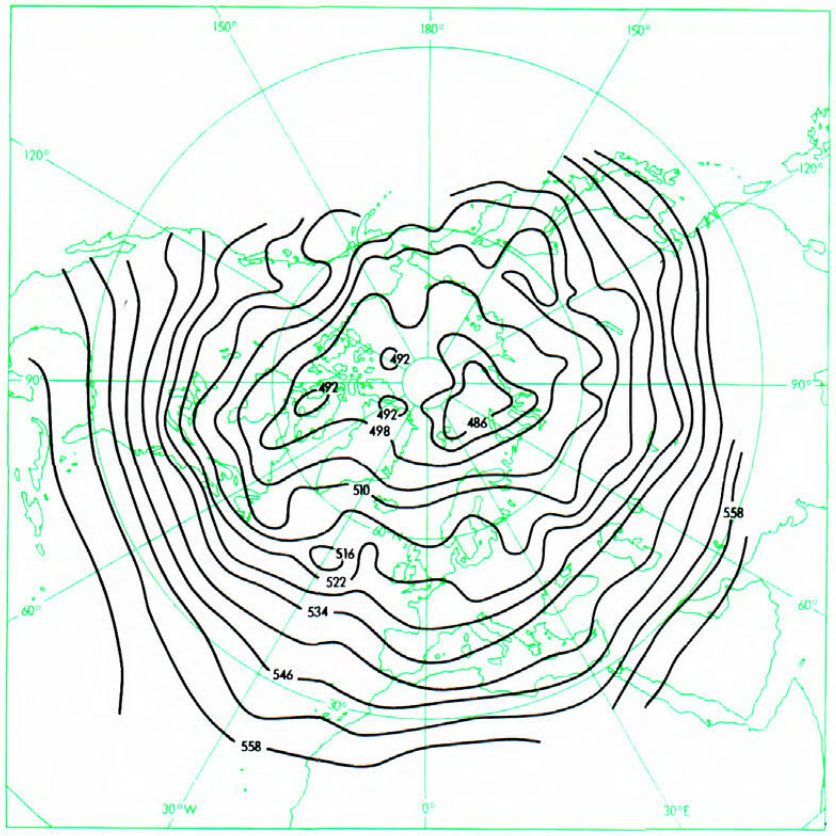

FIGURE 4(e). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR MAY 1951–66
Isopleths are at intervals of 6 geopotential decametres

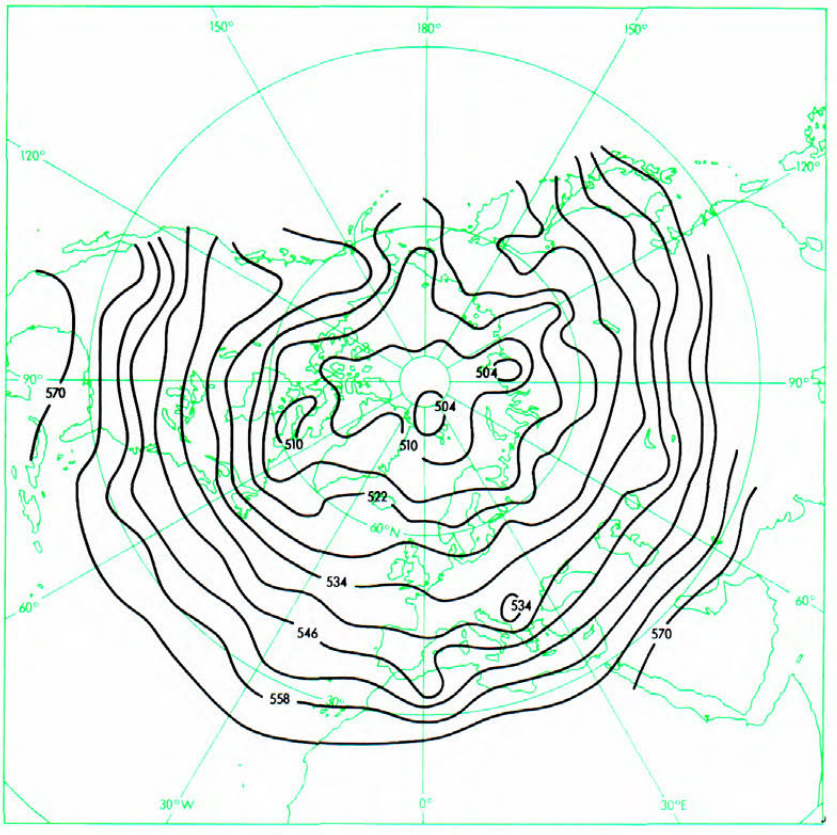

FIGURE 4(f). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR JUNE 1951–66
Isopleths are at intervals of 6 geopotential decametres

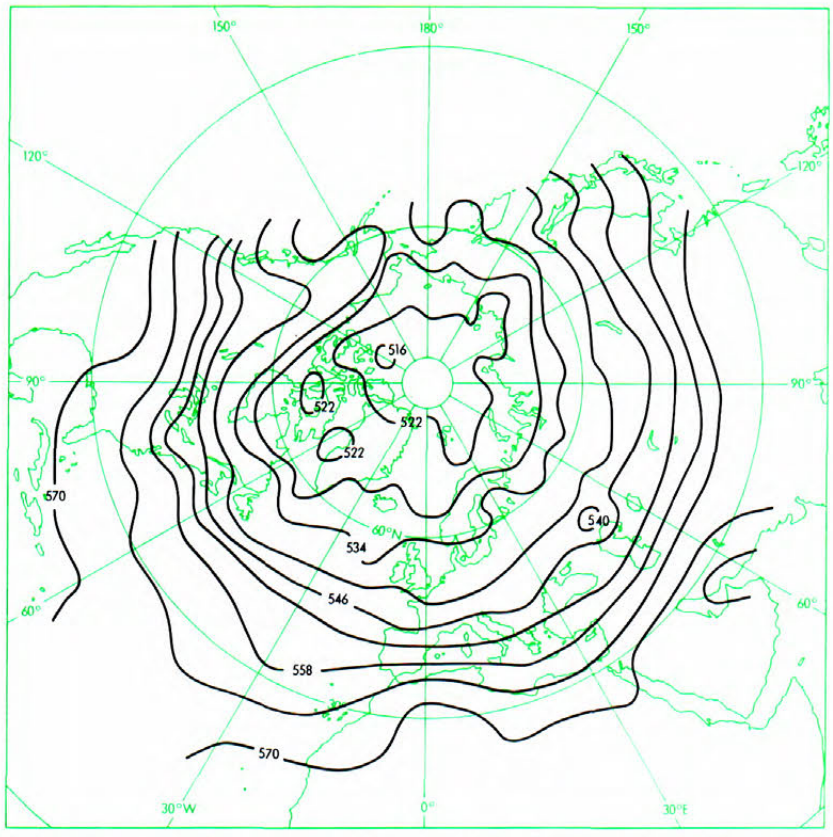

FIGURE 4(g). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR JULY 1951–66
Isopleths are at intervals of 6 geopotential decametres

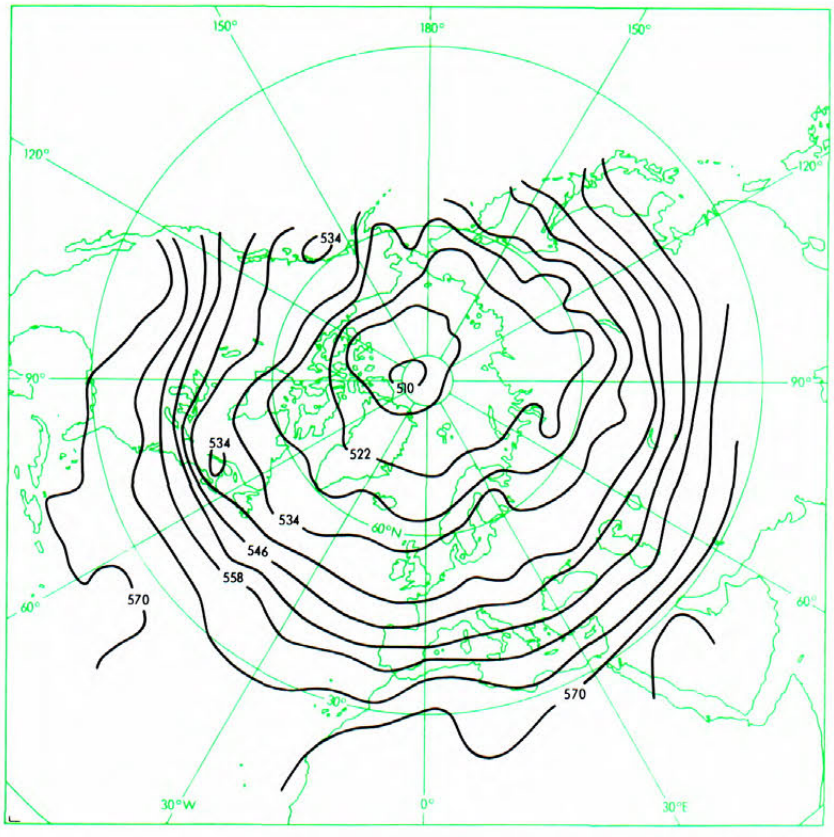

FIGURE 4(h). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR AUGUST 1951–66
Isopleths are at intervals of 6 geopotential decametres

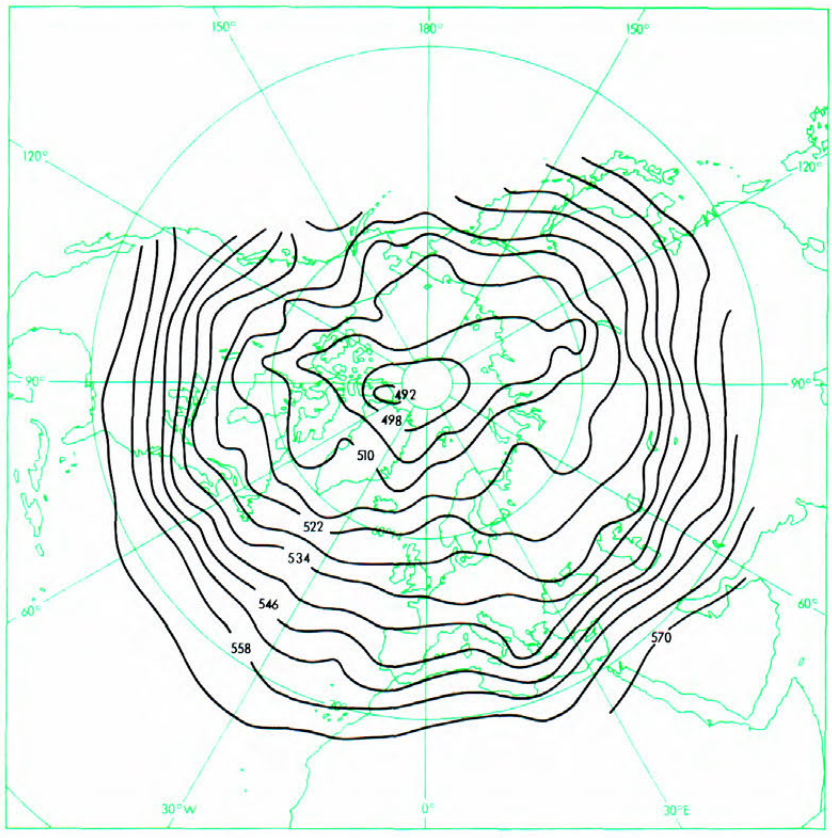

FIGURE 4(i). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR SEPTEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

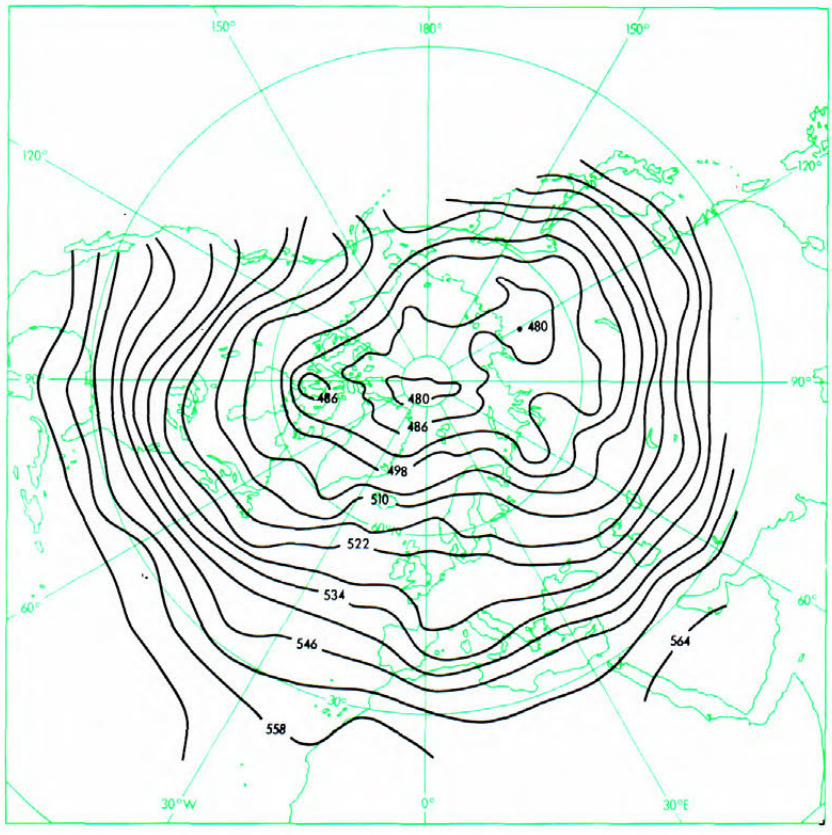

FIGURE 4(j). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR OCTOBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

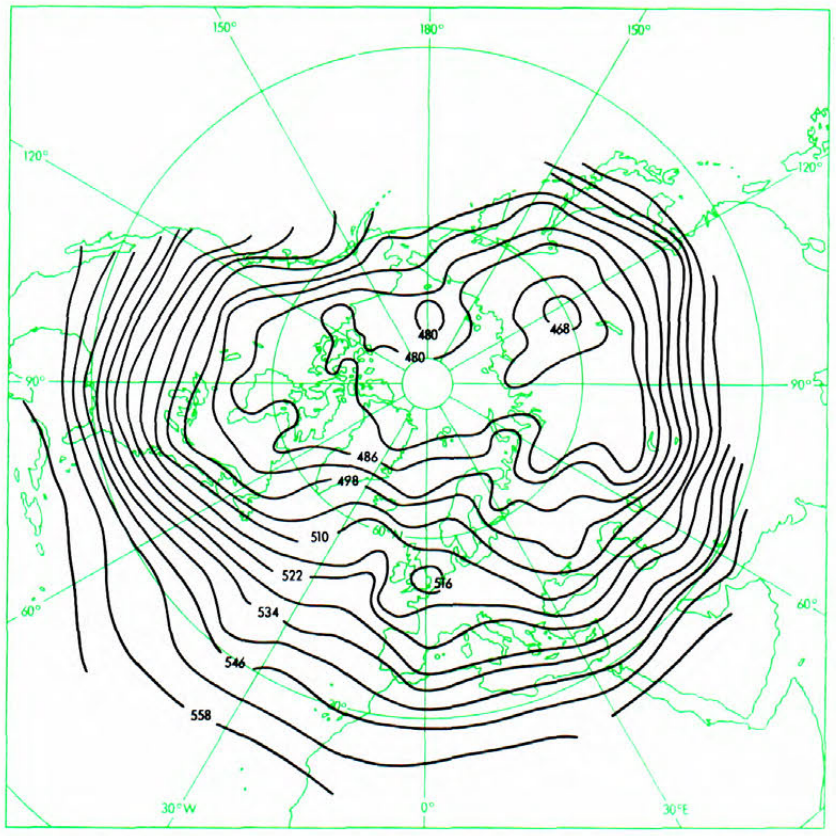

FIGURE 4(k). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR NOVEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

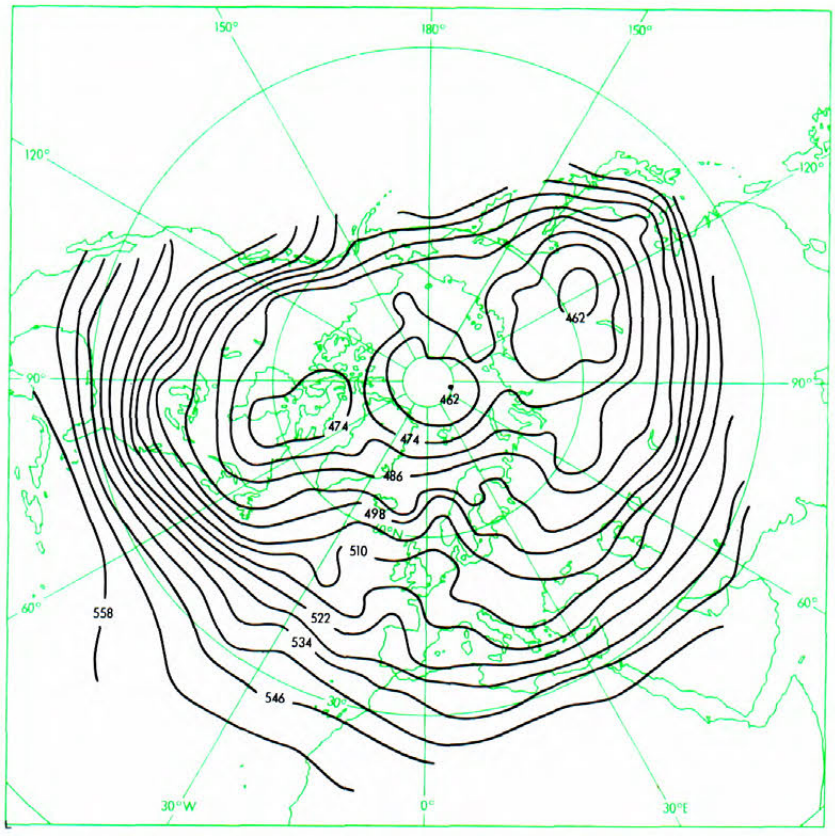

FIGURE 4(l). EXTREME DAILY MINIMUM 1000–500-MILLIBAR THICKNESS FOR DECEMBER 1951–66
Isopleths are at intervals of 6 geopotential decametres

5 – PATTERNS OF STANDARD DEVIATION (500 MILLIBARS)

These patterns are shown in Figures 5(a)–(d). The main area of high standard deviation (S.D.) is the semi-persistent belt extending from the area of the Davis Strait and Newfoundland across Greenland and Iceland to southern Scandinavia and the Urals, though in summer the eastern part curves northward towards the North Pole.

An area of high standard deviation off the west Canadian seaboard in winter moves towards the Aleutians in the summer months and becomes less marked. Although there is a definite high S.D. over the Great Lakes in spring only, there is a marked tendency for high S.D. there in the winter months also, while in the summer months this area of high S.D. moves away east then north towards Baffin Island. There appears to be some degree of correlation between these patterns and the mean frequencies of depressions over a period of 20 years.[3]

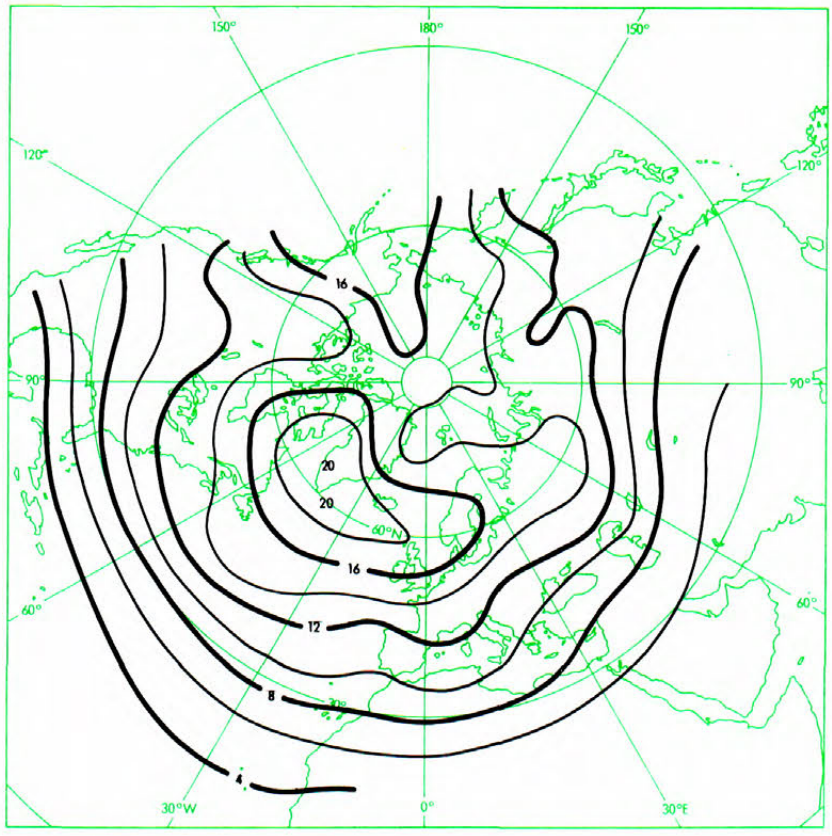

FIGURE 5(a). STANDARD DEVIATION OF 500-MILLIBAR HEIGHT FOR JANUARY 1951–66
Isopleths are at intervals of 2 geopotential decametres

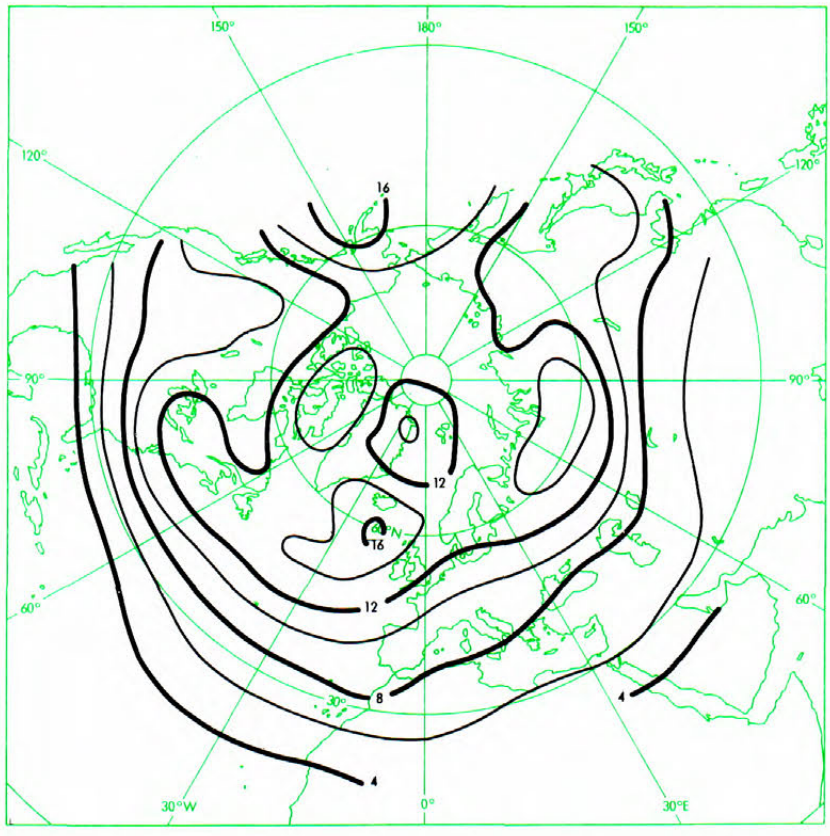

FIGURE 5(b). STANDARD DEVIATION OF 500-MILLIBAR HEIGHT FOR APRIL 1951–66
Isopleths are at intervals of 2 geopotential decametres

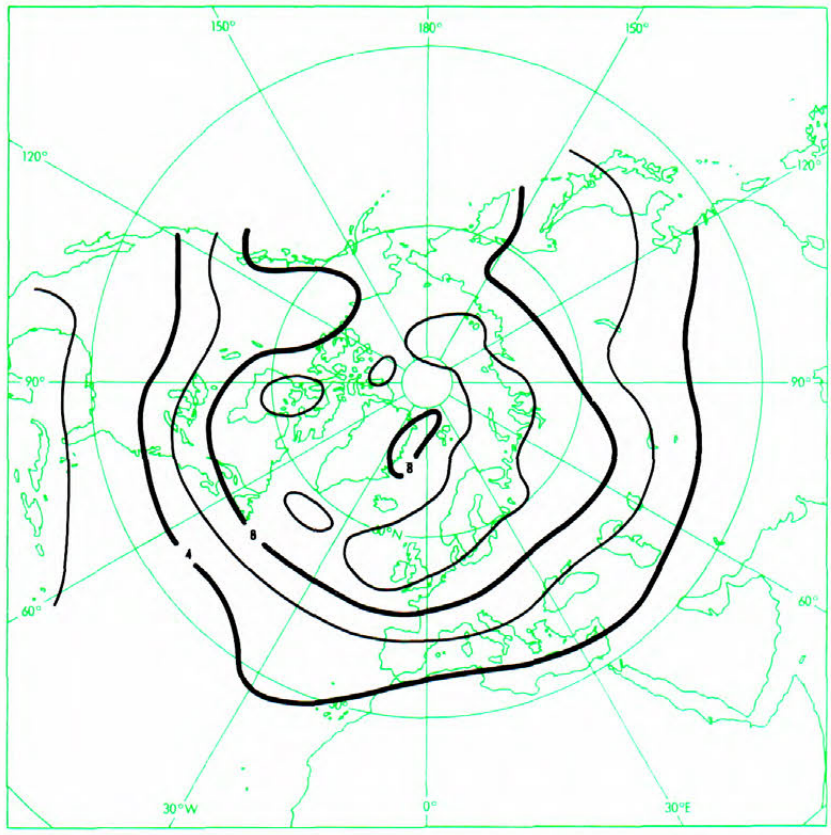

FIGURE 5(c). STANDARD DEVIATION OF 500-MILLIBAR HEIGHT FOR JULY 1951–66
Isopleths are at intervals of 2 geopotential decametres

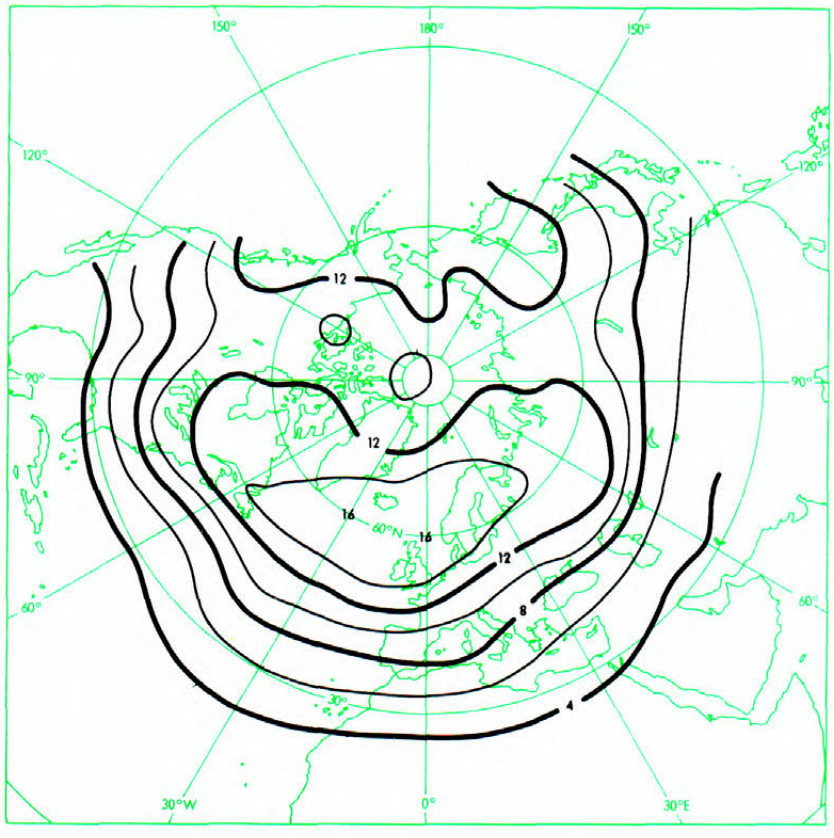

FIGURE 5(d). STANDARD DEVIATION OF 500-MILLIBAR HEIGHT FOR OCTOBER 1951–66
Isopleths are at intervals of 2 geopotential decametres

6 – PATTERNS OF STANDARD DEVIATION (1000–500-MILLIBAR THICKNESS)

Figures 6(a)–(d) illustrate these patterns. High values of S.D. are associated, in general, with the main thickness troughs. Summer patterns are relatively uniform around the Pole. An interesting feature is an area of relatively low S.D. extending northwards towards or over the British Isles for much of the year, though becoming less evident in the summer months. Not surprisingly there appears to be some degree of correlation with the position of the main troughs of the 1000–500-mb thickness averages.

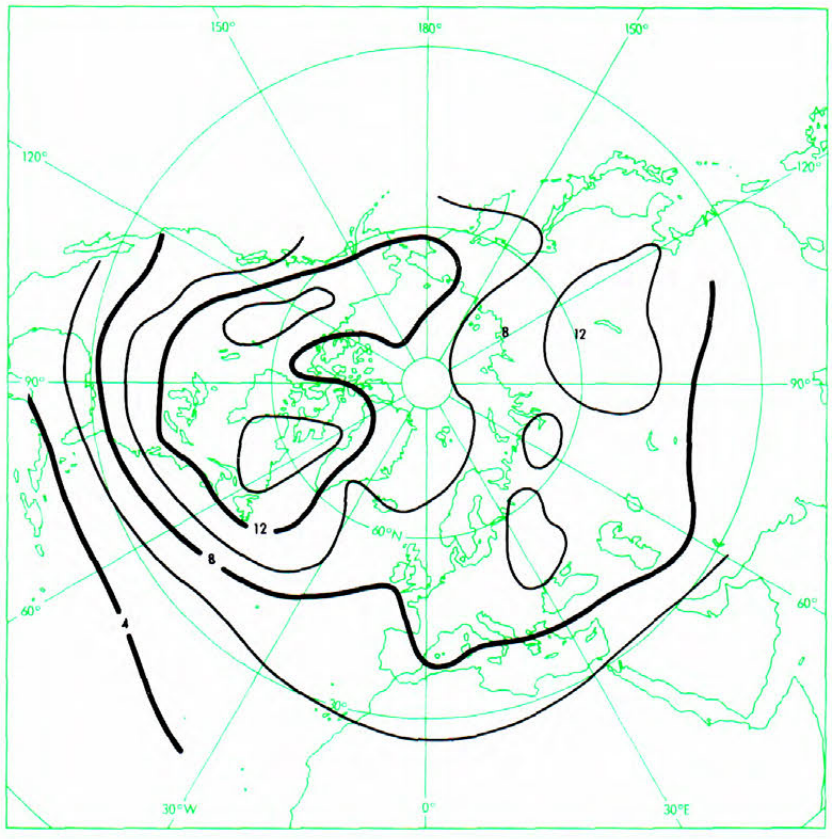

FIGURE 6(a). STANDARD DEVIATION OF 1000–500-MILLIBAR THICKNESS FOR JANUARY 1951–66
Isopleths are at intervals of 2 geopotential decametres

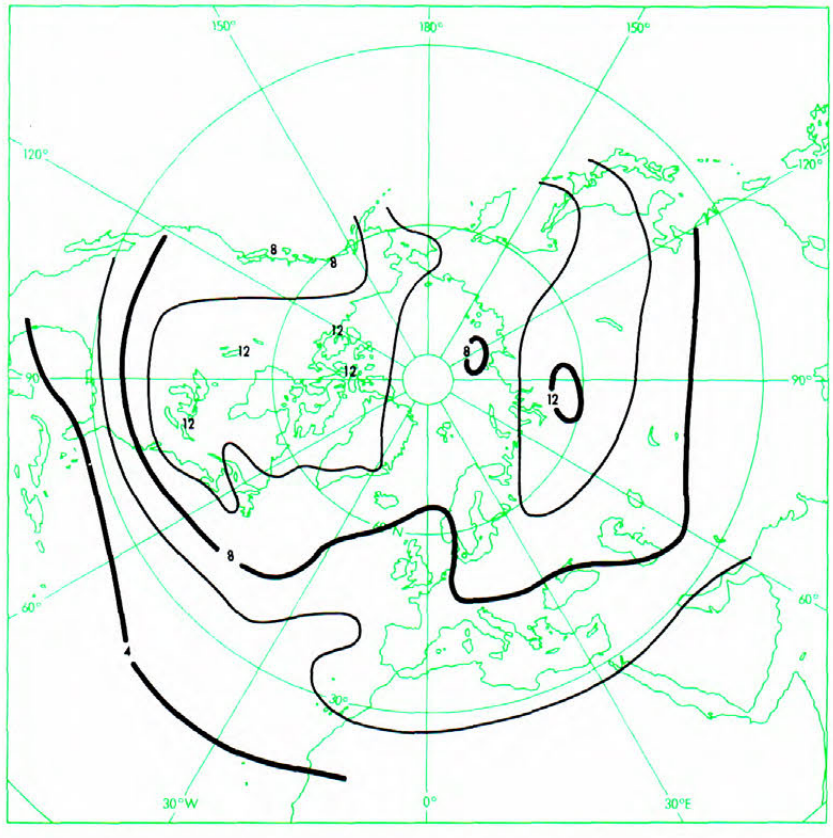

FIGURE 6(b). STANDARD DEVIATION OF 1000–500-MILLIBAR THICKNESS FOR APRIL 1951–66
Isopleths are at intervals of 2 geopotential decametres

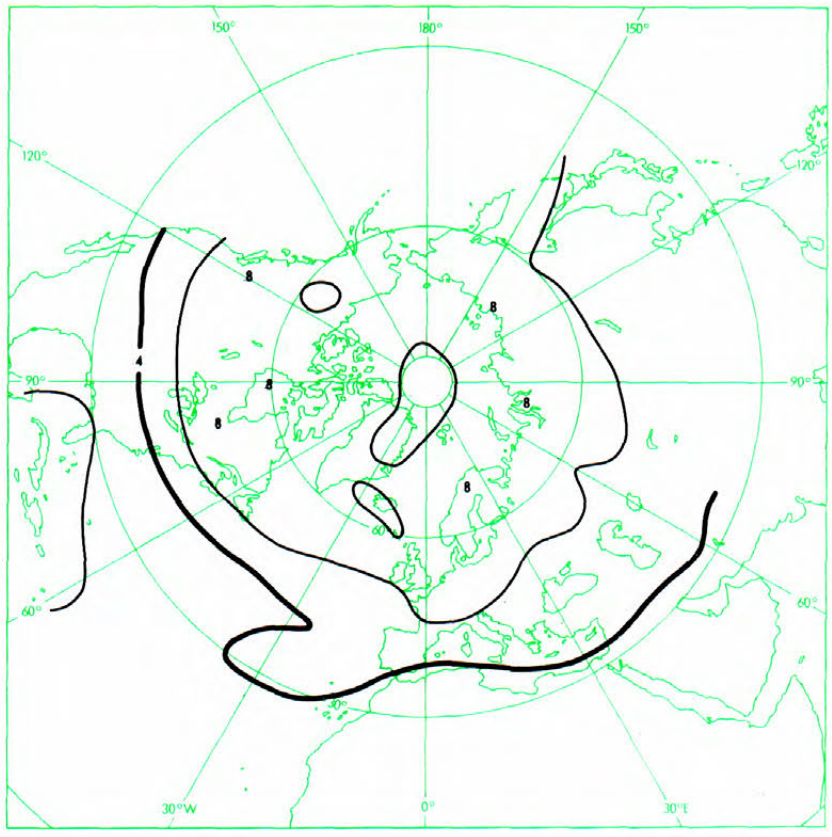

FIGURE 6(c). STANDARD DEVIATION OF 1000–500-MILLIBAR THICKNESS FOR JULY 1951–66
Isopleths are at intervals of 2 geopotential decametres

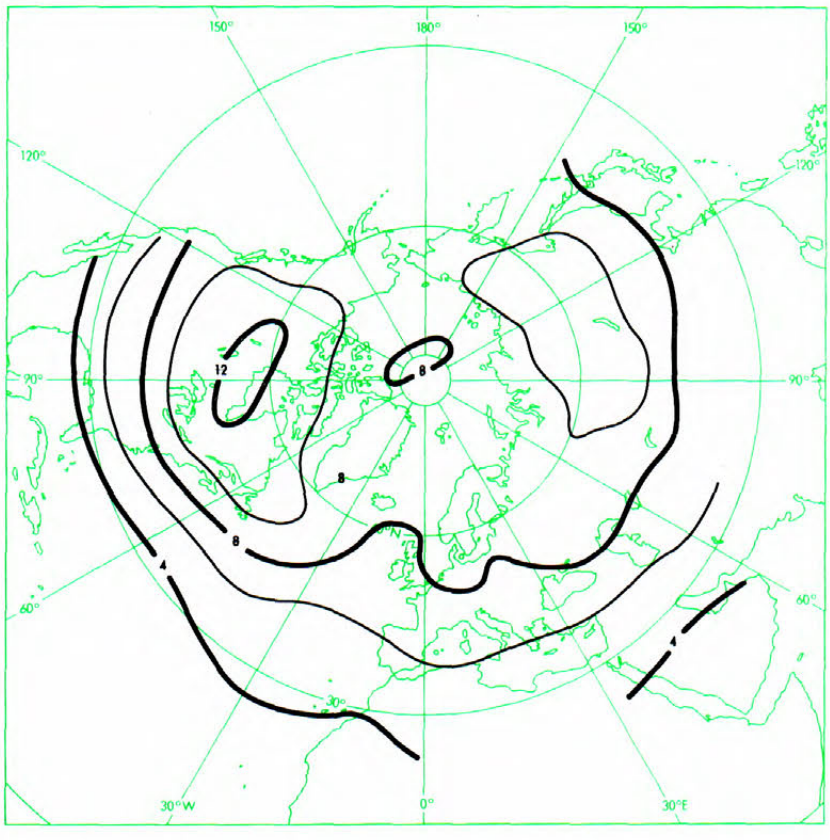

FIGURE 6(d). STANDARD DEVIATION OF 1000–500-MILLIBAR THICKNESS FOR OCTOBER 1951–66
Isopleths are at intervals of 2 geopotential decametres

7 – SKEWNESS PATTERNS (500 MILLIBARS)

These patterns are reproduced in Figures 7(a)–(d). Negative skewness is evident roughly south of 50°N for much of the year, except over the North Pacific. Changes from this general pattern tend to be rather variable and to occur mainly in the Asiatic sector. North of 50°N positive skewness values are common in winter but values become less positive by spring. By summer, most distributions north of 50°N have become normal or show slight negative skewness.

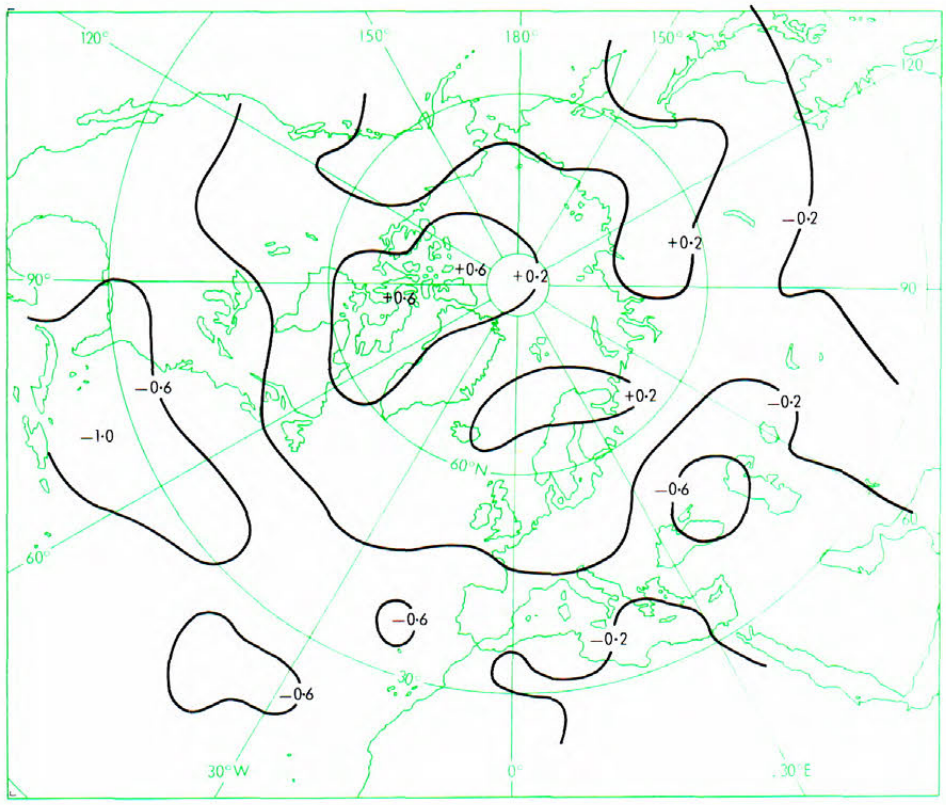

FIGURE 7(a). ISOPLETHS OF SKEWNESS PARAMETER OF 500-MILLIBAR HEIGHT FOR JANUARY 1951–66

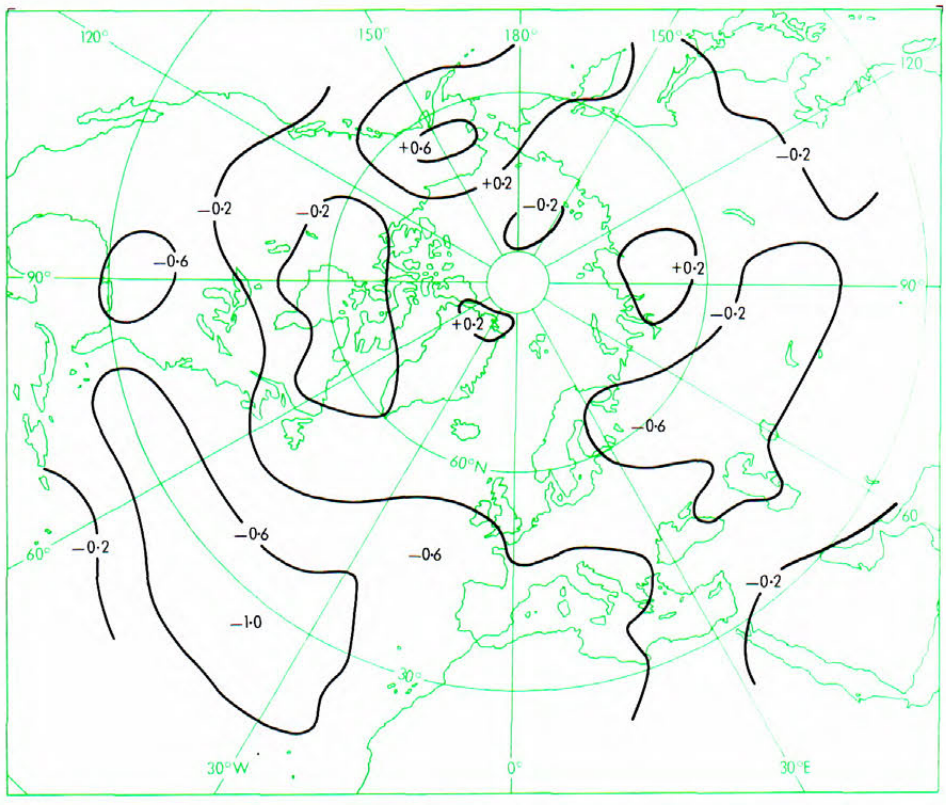

FIGURE 7(b). ISOPLETHS OF SKEWNESS PARAMETER OF 500-MILLIBAR HEIGHT FOR APRIL 1951–66

FIGURE 7(c). ISOPLETHS OF SKEWNESS PARAMETER OF 500-MILLIBAR HEIGHT FOR JULY 1951–66

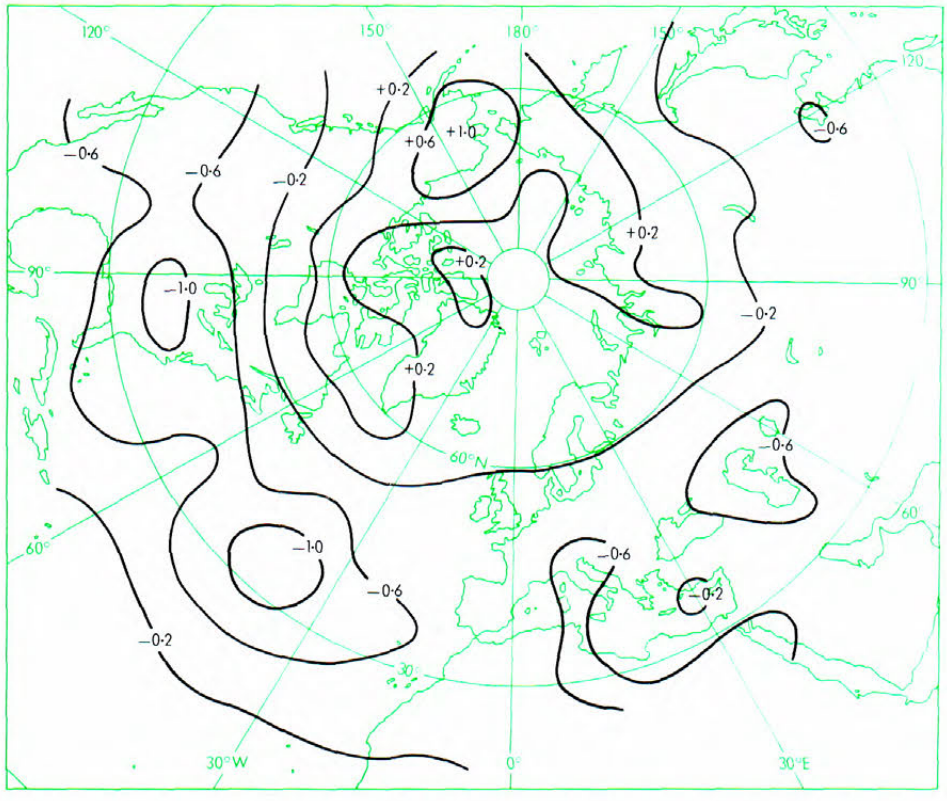

FIGURE 7(d). ISOPLETHS OF SKEWNESS PARAMETER OF 500-MILLIBAR HEIGHT FOR OCTOBER 1951–66

8 – SKEWNESS PATTERNS (1000–500-MILLIBAR THICKNESS)

Figures 8(a)–(d) depict these particular patterns. Although broadly similar to the patterns of 500-mb skewness there appears to be a more pronounced northward migration of the negative skewness zone over the Asiatic sector from mid-spring to mid-autumn, perhaps associated with the monsoon.

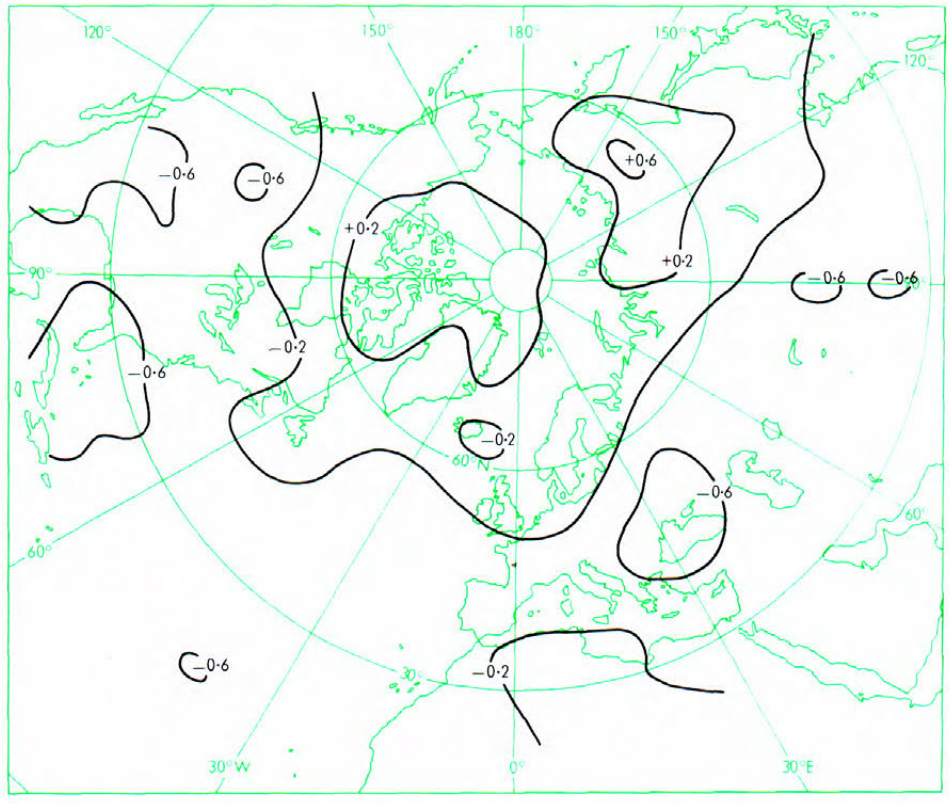

FIGURE 8(a). ISOPLETHS OF SKEWNESS PARAMETER OF 1000–500-MILLIBAR THICKNESS FOR JANUARY 1951–66

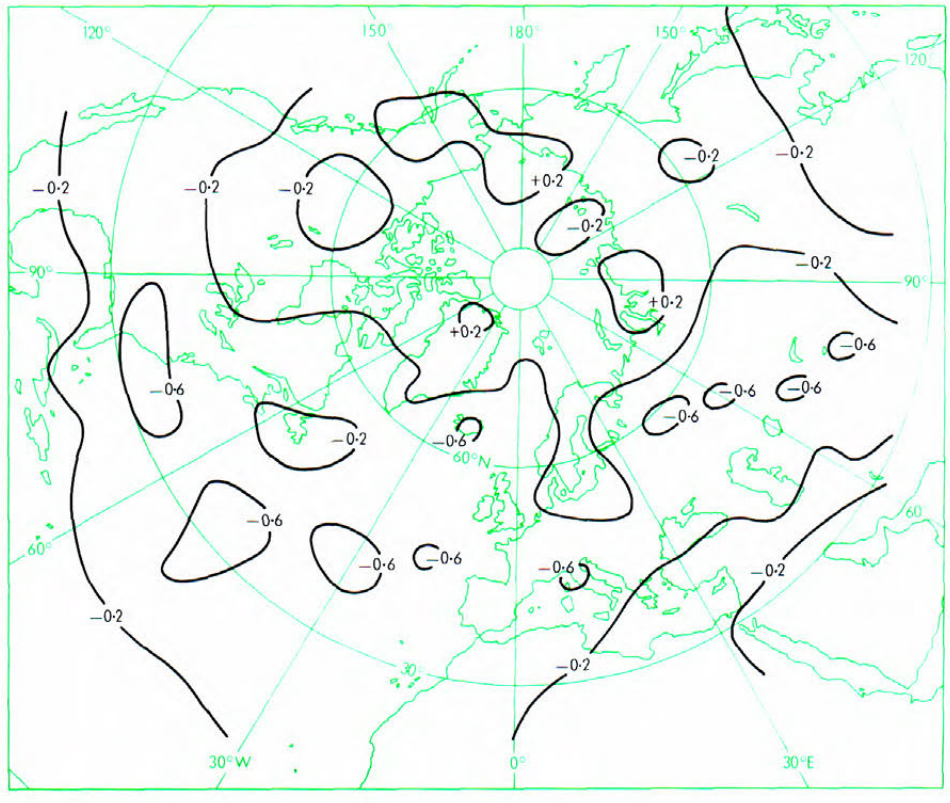

FIGURE 8(b). ISOPLETHS OF SKEWNESS PARAMETER OF 1000–500-MILLIBAR THICKNESS FOR APRIL 1951–66

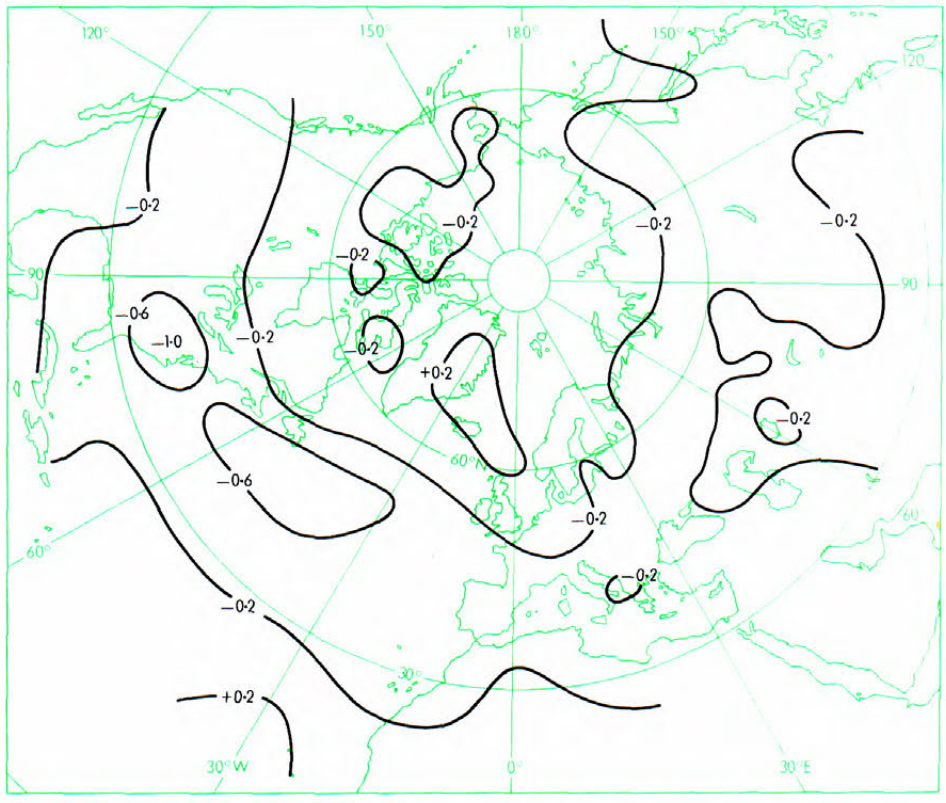

FIGURE 8(c). ISOPLETHS OF SKEWNESS PARAMETER OF 1000–500-MILLIBAR THICKNESS FOR JULY 1951–66

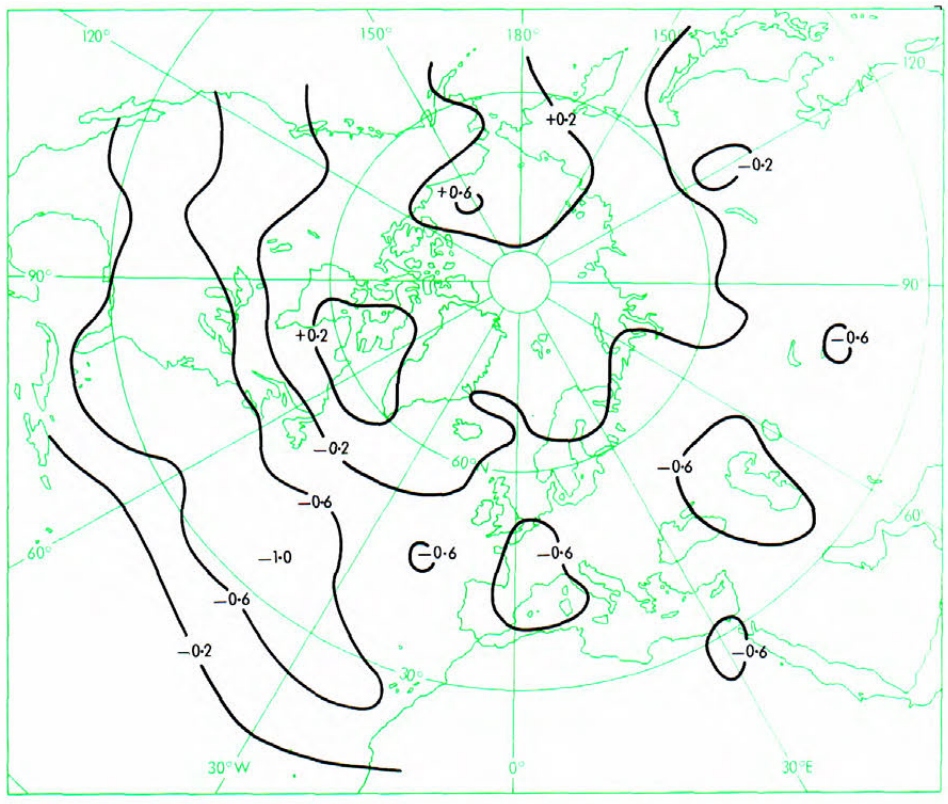

FIGURE 8(d). ISOPLETHS OF SKEWNESS PARAMETER OF 1000–500-MILLIBAR THICKNESS FOR OCTOBER 1951–66

PART II – THE DATA

9 – 500-MILLIBAR HEIGHT CONTOURS

As part of a data exchange in 1965 the Meteorological Office received from the Deutscher Wetterdienst a set of punched cards comprising daily values of 500-mb height at grid points over much of the northern hemisphere for the period 1949–64. The German grid is the points of intersection of each 10 degrees of longitude (i.e. 10°W, 20°W, etc) with each 5 degrees of latitude from 15°N to the North Pole though certain points are omitted north of 65°N. Further, as the German upper air charts from which the data were extracted did not extend to parts of the Pacific Ocean, data are missing for some points south of 50°N. Chart times were for 03 GMT until March 1957 and after that, following international agreement, 00 GMT. Pentad (i.e. 5-day mean) data became available, by courtesy of the Japan Meteorological Agency, for the period from 27 March 1947 to 26 March 1966. Details of their subsequent processing are available elsewhere.[4]

10 – SURFACE PRESSURE

A long series of daily data at grid points over the northern hemisphere, north of 5°N, was supplied by the Extended Forecast Division of the United States Weather Bureau (USWB) in 1967. This series comprises values from 1899 to 1965 though with a break from July 1939 to December 1946. However the USWB grid differs from the British and German grids, so values were interpolated for some points of the British grid.[5] Data for the British grid for all later years have been extracted from Meteorological Office daily surface pressure charts for 00 GMT.

11 – 1000–500-MILLIBAR THICKNESS

A further set of punched cards, received from the Deutscher Wetterdienst in 1965, comprised daily values of 1000–500-mb thickness for the same period and at the same grid points as the 500-mb data.

This series has been extended up to the present by using Meteorological Office charts of surface pressure and 500-mb height for 00 GMT. This extension has been accomplished by an empirical method, devised by the Synoptic Climatology Branch, which is in five stages:

(a) A first approximation of the 1000-mb height is made from the formula:

$$\text{1000-mb height} = \frac{3\,(p-1000)}{4} \text{ geopotential decametres,}$$

where p is the surface pressure in millibars.

(b) These values are subtracted from the 500-mb heights to give a first approximation of the 1000–500-mb thickness (Z_1).

(c) An estimate of the mean temperature (T_m) of the layer from the surface to 1000-mb is made by using three categories of Z_1, from the following empirical formulae:

If $Z_1 \leqslant 478.0$ geopotential decametres, $T_m = [(0.93 \times 478) - 223]$ K.

If $541.5 \geqslant Z_1 > 478.0$ geopotential decametres, $T_m = [(0.93 \times Z_1) - 223]$ K.

If $Z_1 > 541.5$ geopotential decametres, $T_m = [(0.52 \times Z_1) - 1]$ K.

(d) A second approximation is made of the 1000-mb height by using the formula:

$$\text{1000-mb height} = \frac{(p - 1000)\, T_m}{342} \text{ geopotential decametres.}$$

(e) A second approximation of the thickness is made by subtracting these 1000-mb values from the 500-mb heights.

12 – QUALITY CONTROL

Several methods have been used to detect the errors which are bound to occur in data as numerous as these. The distribution of values at each grid point is seldom normal so that methods of quality control based on the probability of a particular value falling outside a given range of values cannot be used. The most practical method was found to be a combination of simple techniques using range, mean and standard deviation at each grid point. The distributions of the daily data used in the computation of each monthly average were determined at each grid point and the following ratios calculated.

$$\text{(a)}\ \frac{\text{Max.} - \text{Min.}}{\text{S.D.}}\ ; \qquad \text{(b)}\ \frac{\text{Max.} - \text{Mean}}{\text{S.D.}}\ ; \qquad \text{(c)}\ \frac{\text{Mean} - \text{Min.}}{\text{S.D.}}\ .$$

All grid points at which the range of values, in units of standard deviation, was greater than limits determined empirically as 6, 4 and 4 respectively were noted. Next, the 10 highest and 10 lowest values were found for these grid points, together with their respective dates, and computer prints of the appropriate daily charts were obtained and compared with the original charts for the same dates. Values considered incorrect were, of course, corrected. This procedure, intended to eliminate large errors while ignoring small ones, was probably the best which could be done with the available resources. The matter is more fully discussed in a planning report recently produced by WMO which covers some aspects of quality control.[6]

PART III – PRODUCTION OF THE CHARTS

13 – GENERAL

All the monthly mean charts have been produced by averaging the daily averages at each grid point. It is considered that data for a period of 16 years are hardly adequate to produce representative mean values for individual days directly, and it was decided to adopt harmonic analysis as a means of smoothing. This idea is not new and has been used by the Japan Meteorological Agency, with six-term coefficients, when producing their 500-mb averages for the period 1946–60.[7] In our case, pentad (i.e. 5-day) averages were formed from the basic data and smoothed daily averages were computed from these by using two-term coefficients.[8]

14 – 500 MILLIBARS

Those pentad values calculated from the German data for 1951–64 did not extend over much of the Pacific and it was necessary to supplement them mainly with pentad values supplied by the Japan Meteorological Agency.[4] Values at certain grid points in this area common to both sets of data were compared by using Student's *t*-test (a reasonable procedure since the distributions do not depart very far from normality) but the discrepancies did not appear to be material. As the Japanese grid did not include values at, for example, 45°N, 35°N and 25°N, only values at 50°N, 40°N and 30°N were interposed by this method. The remaining missing values over the Pacific area were taken from hand-drawn monthly mean charts for 1951–66 available in the Synoptic Climatology Branch of the Meteorological Office. From these values smoothed pentad averages were produced by using two-term coefficients devised by Craddock.[9] At the same time, a two-term harmonic analysis was carried out on the pentad values and smoothed daily averages produced for the chart area. The daily values were then averaged over each month to produce the monthly mean charts.

15 – 1000–500-MILLIBAR THICKNESS

Since 1964 all historical thickness data stored on magnetic tape have been deduced by the method described in an earlier paragraph and it was decided, despite the availability of 14 years' true thickness data over much of the northern hemisphere, to form daily averages by the same method, i.e. by using the averages of 500-mb height and surface pressure to produce 1000–500-mb thickness averages.

16 – EXTREME MAXIMA AND MINIMA

The charts are based on extreme daily values for grid points for which data were available on at least two-thirds of all possible occasions.

17 – STANDARD DEVIATIONS

Standard deviations of the daily values about their respective monthly averages have been computed for each grid point and are reproduced in chart form. There appears to be some degree of correlation between the 500-mb standard deviation patterns and the mean frequencies of depressions[7] over a different period of 20 years. Not surprisingly there also appears to be some degree of correlation between the 1000–500-mb thickness standard deviation patterns and the position of the main troughs of the 1000–500-mb thickness averages.

18 – SKEWNESS

While, as mentioned earlier, the distributions do not depart very far from normality, many are somewhat asymmetrical, and this asymmetry can be measured by the coefficient of skewness, namely the ratio of the third moment of the distribution to the cube of the standard deviation. The standard deviation of this coefficient is approximately $\sqrt{(6/N)}$ (see for example Brooks and Carruthers[10]) and the charts (Figures 6(a) to 6(d)) show the coefficient of skewness for each point divided by its own S.D. (skewness parameter). While the individual values may be in doubt the general character of the variation of the coefficient of skewness over the northern hemisphere is quite clear.

Some typical histograms for January and July have been included as Figures 9 and 10 to show the change in frequency distribution from winter to summer. In general, values are much more closely distributed about the mean in summer, particularly in the lower latitudes, while the range generally tends to decrease in summer.

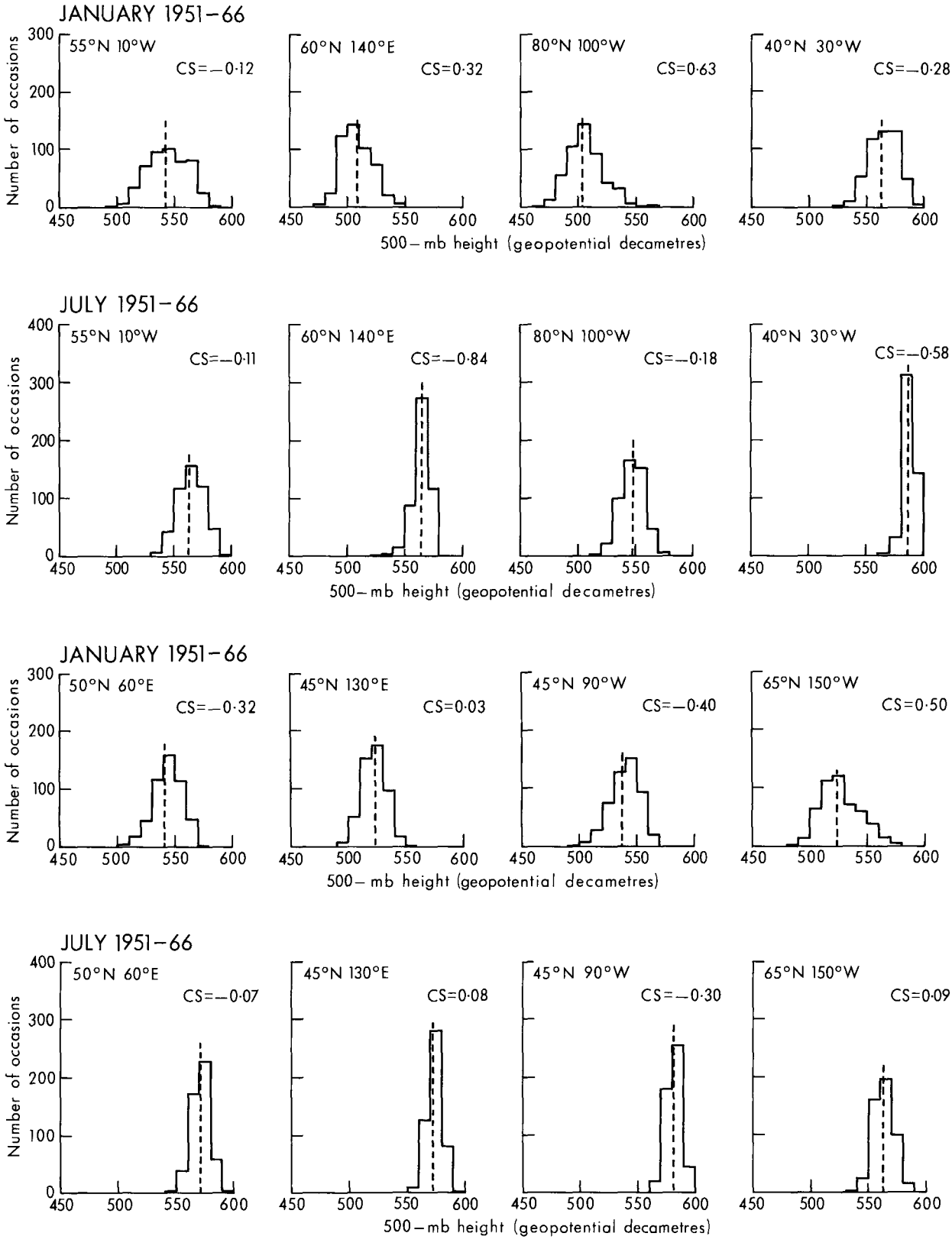

FIGURE 9. DAILY FREQUENCY DISTRIBUTION OF 500-MILLIBAR HEIGHT AT SELECTED GRID POINTS FOR JANUARY AND JULY, 1951–66

—— Observed distribution

– – – Mean value for 1951–66 at specified grid point

CS Coefficient of skewness

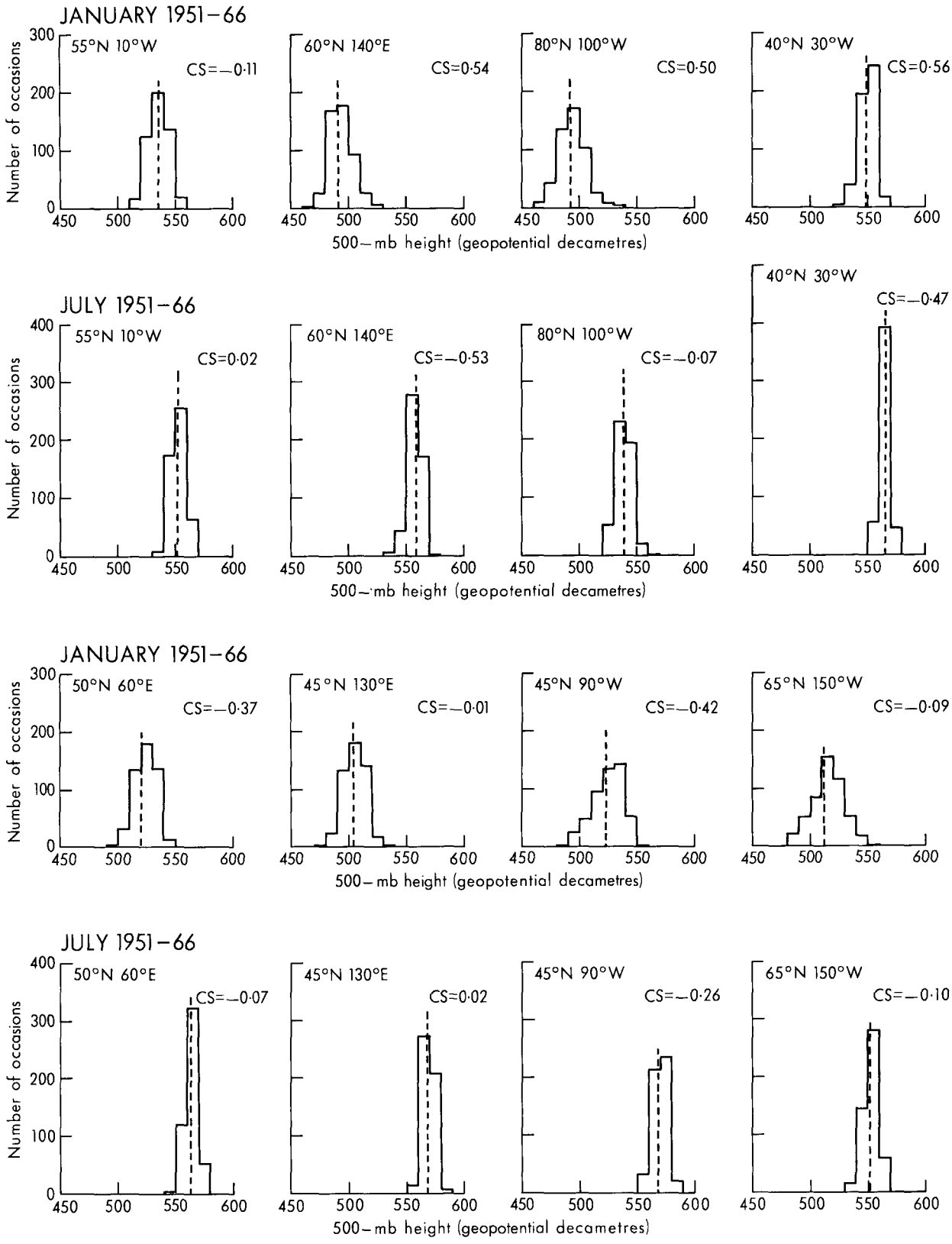

FIGURE 10. DAILY FREQUENCY DISTRIBUTION OF 1000–500-MILLIBAR THICKNESS AT SELECTED GRID POINTS FOR JANUARY AND JULY, 1951–66

—— Observed distribution

– – – Mean value for 1951–66 at specified grid point

CS Coefficient of skewness

PART IV – EXTREME MAXIMA AND MINIMA OF 500-MILLIBAR HEIGHT

19 – TABULATIONS OF EXTREME MAXIMA AND MINIMA OF 500-MILLIBAR HEIGHT

EXTREME VALUES OF 500-MB CONTOURS. 1951-66
JANUARY

LATITUDE DEGREES NORTH	170 W	160 W	150 W	140 W	130 W	120 W	110 W	100 W	90 W	80 W	70 W	60 W	50 W	40 W	30 W	20 W	10 W	0	10 E	20 E	30 E	40 E	50 E	60 E	70 E	80 E	90 E	100 E	110 E	120 E	130 E	140 E	150 E	160 E	170 E	180
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		546																		
85									564									542								542									550
80		556		565		568		566		566		567		560		544		544		545		544		542		545		546		545		544		551		555
75		563		564		559		554		554		558		560		555		555		549		549		542		553		553		553		551		555		566
70		567		557		552		545		557		565		558		565		562		560		559		549		552		557		556		549		556		565
65	574	577	575	572	568	560	553	549	552	556	558	564	564	563	570	576	571	573	570	565	566	565	565	555	557	556	552	549	548	543	542	548	555	557	561	562
60	577	583	580	581	573	567	559	552	557	565	570	566	566	570	575	578	575	573	572	568	568	563	565	560	562	560	559	552	551	544	545	549	549	554	575	568
55	575	575	577	585	578	576	572	555	561	566	574	579	578	582	576	581	580	579	579	578	569	564	566	569	570	566	562	564	557	550	545	543	545	550	560	576
50			581	585	579	581	577	567	565	562	570	577	585	588	584	584	584	584	580	573	570	565	568	573	573	571	569	565	554	556	542	537	549	550	564	
45					586	587	583	574	569	561	566	570	581	587	589	585	583	583	577	572	572	572	570	570	573	574	569	567	558	556	556	550	552				
40						589	585	578	574	579	579	581	586	592	595	589	587	584	576	576	573	577	575	576	574	574	573	572	566	562	565	560	564				
35						589	588	585	583	589	588	586	592	593	593	589	590	586	582	582	578	578	577	580	579	578	578	576	573	574	573	572					
30							590	591	591	593	592	592	594	594	593	593	590	588	588	586	584	585	582	583	584											
25							590	594	595	594	594	593	593	594	593	593	592	590	590	589	588	589	589	589												
20							593	593	594	594	594	594	595	595	594	594	594					593														
15												594	594	594	596	597																				
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		474																		
85									466									468								464									474
80		472		471		472		467		463		465		474		468		467		474		471		469		470		467		460		464		473		479
75		469		476		472		461		458		468		477		474		478		475		475		469		466		471		467		471		479		479
70		483		487		474		467		466		463		466		470		480		479		480		474		473		478		478		471		479		484
65	492	489	489	490	492	484	474	471	472	468	466	460	473	468	468	485	482	484	486	483	486	486	486	476	475	476	483	480	479	480	480	476	479	480	482	486
60	491	490	491	493	490	492	487	484	476	466	467	471	468	474	472	490	493	495	492	490	491	492	491	480	482	486	490	488	480	480	482	472	465	481	480	491
55	484	483	492	495	487	501	496	484	479	474	468	476	468	479	472	491	492	507	503	504	494	499	498	493	500	504	504	498	490	486	483	467	464	476	487	483
50			483	495	501	515	510	498	489	486	488	484	480	494	498	512	508	513	515	505	501	501	499	506	513	517	513	512	500	492	481	480	480	482	491	
45					516	522	520	510	497	496	495	498	499	503	520	525	527	519	515	516	510	514	509	511	518	531	525	519	510	500	492	495	488				
40						527	526	525	515	508	504	503	514	520	527	528	535	521	522	524	520	523	524	520	538	540	536	526	520	512	503	504	502				
35						533	540	537	528	527	532	520	533	534	538	536	539	537	526	535	536	539	538	532	544	546	545	534	528	524	520	520					
30							548	552	546	548	539	540	548	546	547	546	551	548	544	545	550	545	548	553	550											
25							560	556	560	560	557	558	563	556	550	559	558	550	556	558	559	557	556	558												
20							564	567	575	572	573	570	571	559	561	567	564					567														
15												578	575	567	572	570																				

EXTREME VALUES OF 500-MB CONTOURS.1951-66
FEBRUARY

MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES

LATITUDE DEGREES NORTH	170 W	160 W	150 W	140 W	130 W	120 W	110 W	100 W	90 W	80 W	70 W	60 W	50 W	40 W	30 W	20 W	10 W	0	10 E	20 E	30 E	40 E	50 E	60 E	70 E	80 E	90 E	100 E	110 E	120 E	130 E	140 E	150 E	160 E	170 E	180
90																		541																			
85									549									547									545									546
80		546		550		547		552		553		550		552		554		548		550		552		553		554		548		544		546		548		542
75		552		550		541		548		551		556		564		556		550		555		568		563		562		559		554		554		554		553
70		565		561		549		548		550		558		566		571		565		565		572		570		563		558		552		553		556		563
65	570	573	569	567	559	558	559	551	544	547	552	557	566	572	575	577	578	578	577	570	572	566	573	572	569	562	557	551	549	547	544	547	549	556	561	566
60	578	577	574	571	564	565	564	553	549	548	556	559	571	573	580	579	580	580	576	568	567	564	566	568	569	561	563	552	546	544	544	542	546	549	557	570
55	580	582	580	574	576	570	569	561	562	554	556	561	570	577	577	579	583	580	576	572	570	566	572	568	568	565	560	559	555	544	540	537	538	543	553	567
50			581	582	581	579	580	569	567	564	568	570	571	578	584	584	582	588	579	577	570	568	570	566	569	567	566	563	555	550	540	542	541	545	558	
45					583	585	588	573	572	569	573	572	575	581	589	588	583	581	580	576	570	567	566	569	568	570	570	568	567	557	555	556	557				
40						589	586	579	575	576	579	585	592	589	587	586	589	589	582	578	573	572	573	570	571	573	576	577	576	568	566	570	568				
35						586	586	583	584	584	586	592	597	593	590	589	590	592	583	580	580	578	578	579	580	589	590	589	582	580	580	577					
30							589	589	587	591	594	592	591	591	593	589	589	593	586	585	585	582	583	586	584											
25							590	590	591	595	595	594	594	594	593	590	590	591	590	588	588	590	589	590												
20							592	591	594	595	595	593	593	596	594	592	593					594														
15												593	594	594	594	594																				

MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES

LATITUDE DEGREES NORTH	170 W	160 W	150 W	140 W	130 W	120 W	110 W	100 W	90 W	80 W	70 W	60 W	50 W	40 W	30 W	20 W	10 W	0	10 E	20 E	30 E	40 E	50 E	60 E	70 E	80 E	90 E	100 E	110 E	120 E	130 E	140 E	150 E	160 E	170 E	180
90																		464																			
85									471									464									471									470
80		475		469		465		463		468		465		476		475		480		478		473		468		468		464		468		472		473		471
75		476		470		474		470		471		470		476		478		480		479		480		471		470		471		479		471		475		481
70		477		479		476		467		467		472		478		484		491		490		484		478		478		477		482		475		482		483
65	482	484	491	488	490	481	477	475	466	464	470	471	475	477	483	488	488	490	495	490	485	486	477	484	482	480	480	476	480	485	483	480	486	484	486	486
60	486	488	487	495	492	489	484	481	471	468	476	476	480	476	488	490	498	499	498	483	485	485	486	486	482	474	483	483	483	485	485	483	483	478	484	485
55	491	494	498	492	492	505	501	493	481	480	481	482	480	491	491	492	491	500	500	495	497	497	486	487	482	493	497	498	493	492	487	484	484	483	491	491
50			490	500	506	514	516	505	495	482	482	483	486	497	498	504	502	506	507	507	507	505	498	501	498	510	510	505	504	491	488	487	486	492	492	
45					520	525	522	521	503	504	500	499	504	505	508	508	514	518	508	514	515	523	516	522	525	523	519	517	510	504	497	493	488				
40						534	531	520	520	506	503	520	522	521	519	522	522	520	515	516	521	530	526	530	536	544	540	528	516	511	504	502	504				
35						538	539	537	532	522	523	529	534	531	533	538	530	527	529	528	532	533	540	542	543	549	547	537	520	511	510	512					
30							546	546	546	546	542	548	547	545	547	548	546	539	541	544	544	546	554	553	554											
25							554	559	562	566	562	563	556	559	558	558	558	554	556	557	557	558	562	561												
20							556	572	571	575	576	572	567	564	566	564	566					569														
15												575	575	574	570	566																				

EXTREME VALUES OF 500-MB CONTOURS. 1951-66
MARCH

LATITUDE DEGREES NORTH	LONGITUDE																																							
	DEGREES WEST																		DEGREES EAST																					
	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																								
90																		546																						
85									551									547									551													555
80		557		553		552		551		551		552		557		544		549		554		553		548		548		542		551		559		564		560			
75		565		552		553		557		556		554		567		555		563		554		557		544		549		542		545		551		557		561			
70		569		560		556		549		556		563		577		562		562		561		562		555		553		551		539		558		557		562			
65	571	569	573	570	562	558	554	555	561	562	562	568	578	580	571	565	568	568	569	569	565	566	561	561	558	556	558	555	550	549	549	558	562	562	562	564				
60	567	570	574	571	573	564	564	557	556	563	566	571	576	580	571	575	573	576	575	573	567	565	567	570	566	564	562	557	553	553	551	558	569	566	563	571				
55	572	575	576	577	579	570	570	561	555	563	569	572	575	581	577	575	582	581	578	571	570	566	571	574	573	567	568	561	561	558	557	556	560	564	562	569				
50			580	584	582	574	573	568	561	565	565	571	575	577	577	581	586	584	581	574	569	565	570	575	574	571	575	569	563	557	554	553	558	564	564					
45					585	580	576	572	569	569	572	574	576	583	585	584	583	583	578	574	570	570	573	573	573	575	576	573	566	563	562	553	559							
40						583	580	578	579	579	576	577	583	585	587	587	587	581	579	575	576	573	573	574	580	581	581	579	575	574	570	568	573							
35						584	583	581	585	588	584	587	586	590	590	590	588	586	583	584	585	580	577	582	583	585	584	582	580	579	578	578								
30							589	587	590	590	591	593	593	593	596	597	590	591	588	589	586	583	583	585	588														
25							592	591	593	593	594	594	594	597	600	602	601	593	590	590	589	589	589	589															
20							593	593	594	594	594	594	594	598	598	598	599					591																
15												594	594	597	598	598																						
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																								
90																		462																						
85									468									475									464													460
80		469		466		467		468		472		473		482		482		480		473		478		468		466		460		460		466		478		472			
75		476		477		475		475		468		475		483		482		482		483		476		475		469		452		456		466		486		483			
70		478		481		482		479		467		476		485		492		488		488		487		482		477		467		478		478		488		483			
65	489	490	488	490	493	492	486	470	467	467	475	483	479	483	486	494	492	496	492	492	494	492	491	483	476	480	474	475	483	486	484	486	490	488	484	493				
60	489	493	488	492	492	501	496	490	480	481	480	478	488	480	494	500	502	503	500	498	500	494	491	487	489	487	490	489	489	486	489	486	487	487	483	490				
55	497	498	491	492	506	508	508	499	490	487	482	483	499	493	502	505	504	505	505	508	503	497	497	502	502	502	504	504	499	496	491	485	475	490	486	491				
50			497	500	505	510	515	509	500	495	485	492	495	497	506	506	511	510	516	516	515	505	506	497	502	514	522	519	506	496	494	492	492	494	496					
45					517	517	523	522	512	504	501	507	504	508	513	516	516	516	514	520	524	523	523	509	530	534	537	530	522	507	497	495	500							
40						531	531	524	522	518	511	520	521	518	522	523	528	523	526	517	526	527	531	536	540	550	547	542	532	522	511	508	512							
35						531	538	534	528	528	524	523	536	528	537	536	540	536	532	536	539	537	543	548	551	557	551	551	546	535	528	524								
30							546	549	550	540	534	542	547	545	546	552	548	549	546	552	550	552	554	559	559														
25							555	566	562	564	559	563	554	557	559	559	557	558	560	559	560	562	561	563															
20							556	573	576	578	576	569	564	561	564	567	565					571																
15												574	572	568	577	571																						

EXTREME VALUES OF 500-MB CONTOURS.1951-66
APRIL

LATITUDE DEGREES NORTH	170 W	160 W	150 W	140 W	130 W	120 W	110 W	100 W	90 W	80 W	70 W	60 W	50 W	40 W	30 W	20 W	10 W	0	10 E	20 E	30 E	40 E	50 E	60 E	70 E	80 E	90 E	100 E	110 E	120 E	130 E	140 E	150 E	160 E	170 E	180
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		554																		
85									556									557								552										553
80		553		553		556		554		558		561		555		553		550		553		555		552		552		554		556		558		553		554
75		562		556		558		560		557		555		558		556		556		557		562		560		555		553		552		556		559		563
70		570		569		565		559		560		559		568		565		568		559		563		565		566		564		557		557		565		568
65	576	580	581	580	570	569	565	558	562	561	564	564	568	569	569	571	574	571	573	570	568	567	571	573	574	577	573	567	561	560	553	553	558	562	565	570
60	584	582	583	584	576	572	568	561	566	568	569	561	571	575	578	578	582	574	571	573	571	575	581	577	574	571	568	562	559	557	551	557	565	565	570	576
55	584	583	582	578	580	573	569	574	573	573	572	565	579	582	580	582	581	582	579	578	575	581	585	582	577	573	568	564	562	561	557	558	560	569	573	577
50			585	581	581	574	577	579	580	571	573	570	583	582	583	585	583	582	578	577	575	578	582	582	580	572	572	570	566	563	564	564	564	575	577	
45					585	582	582	579	581	578	579	581	584	588	588	587	584	578	576	574	578	580	582	585	580	579	577	575	576	574	569	571	572			
40						589	588	583	582	588	587	585	588	590	594	586	586	583	581	576	578	582	581	582	585	585	582	581	580	579	580	577	578			
35						590	592	587	586	589	589	588	591	589	593	589	589	587	584	585	588	585	584	588	590	594	590	586	584	583	585	586				
30							591	591	590	590	589	590	593	593	594	594	593	589	589	589	590	590	589	590	594											
25							593	593	596	591	592	593	593	595	597	595	593	592	593	593	594	591	594	594												
20							594	595	596	594	595	594	594	597	598	594	596					593														
15												594	596	596	597	594																				
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		487																		
85									483									488								483										482
80		485		487		480		476		478		486		494		494		487		485		484		480		482		490		483		483		477		478
75		491		493		486		476		477		479		491		499		493		486		487		483		488		490		486		481		484		491
70		499		501		490		476		478		488		489		491		500		498		492		496		491		488		486		489		490		495
65	495	503	506	509	503	490	488	486	477	470	475	486	494	489	486	491	504	499	498	499	491	492	500	497	493	480	476	484	480	483	492	486	495	496	493	492
60	499	501	500	513	512	503	496	492	498	490	488	491	492	496	503	502	501	504	507	507	502	498	503	498	495	480	483	489	486	490	494	497	491	496	492	499
55	496	498	502	508	517	521	510	495	495	490	493	492	497	501	506	512	512	510	514	516	512	509	511	504	507	507	503	500	504	498	503	498	498	501	497	495
50			503	510	519	529	527	516	512	499	500	491	492	514	512	515	519	523	521	521	523	518	520	517	521	524	526	523	519	510	503	501	501	500	499	
45					518	532	537	532	522	519	505	510	518	516	516	516	529	532	527	526	530	523	526	538	540	537	537	536	532	518	507	504	510			
40						531	538	537	527	521	520	520	526	533	533	532	532	535	532	534	537	528	532	544	547	553	551	548	539	526	519	514	518			
35						543	543	546	542	545	534	540	543	546	544	539	542	540	542	546	541	537	548	554	555	560	556	556	552	542	537	534				
30							554	562	554	557	552	552	553	548	552	551	554	551	556	560	557	553	561	560	563											
25							566	566	572	571	565	568	561	558	562	563	560	558	565	568	564	563	569	567												
20							567	578	579	579	574	578	570	568	571	571	570					568														
15												581	577	576	577	576																				

EXTREME VALUES OF 500-MB CONTOURS.1951-66
MAY

LATITUDE DEGREES NORTH	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
	LONGITUDE DEGREES WEST																	LONGITUDE DEGREES EAST																			
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		561																		
85									562									555								562										567
80		574		566		561		558		558		560		560		558		565		564		565		566		565		564		567		565		570		573
75		568		565		566		566		564		564		570		565		567		570		572		573		565		564		569		565		563		571
70		573		573		576		574		570		565		570		571		572		574		577		571		566		566		568		564		567		565
65	565	569	573	578	575	574	579	581	577	572	573	572	572	573	574	576	574	580	579	578	580	581	582	577	574	576	581	576	571	567	567	568	569	570	569	567
60	570	573	576	580	578	577	578	580	577	578	572	576	573	578	576	578	581	579	579	579	579	582	586	581	585	584	584	579	572	568	570	571	572	568	565	567
55	579	581	580	582	581	582	581	580	578	579	575	572	575	582	585	587	586	582	582	581	583	583	588	585	590	589	585	575	571	572	569	573	572	576	576	576
50			585	592	586	581	582	583	581	584	580	578	584	588	592	597	590	584	585	582	589	584	585	586	589	587	584	577	577	576	573	573	574	581	581	
45					588	586	586	586	589	594	586	581	589	593	592	598	592	589	584	583	584	583	583	589	585	586	585	583	582	582	577	577	577			
40						590	590	592	590	591	589	585	592	593	593	596	593	589	588	585	584	588	585	592	588	588	586	586	585	585	585	581	581			
35						592	594	593	593	596	590	593	592	594	596	593	593	593	591	590	590	589	589	597	592	590	590	590	589	589	587	586				
30							597	594	596	594	593	597	596	597	597	594	594	600	598	596	593	593	592	592	593											
25							597	595	594	593	594	598	600	598	597	596	596	601	601	598	596	594	595	596												
20							596	595	594	597	593	598	601	599	598	598	600					596														
15												597	598	598	598	598																				
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		507																		
85									502									507								496										500
80		505		508		502		502		503		503		503		507		502		486		488		485		490		490		496		500		504		504
75		508		509		504		505		503		499		507		495		506		496		492		492		499		500		502		504		500		503
70		508		510		508		507		499		507		510		504		504		504		505		507		502		503		503		511		508		503
65	504	504	517	519	522	522	516	508	506	496	494	501	506	507	507	505	516	508	508	515	518	512	508	507	504	510	507	504	507	509	509	510	506	506	506	507
60	510	513	514	515	523	521	525	516	506	503	504	507	508	508	508	506	516	519	518	520	520	521	516	507	500	510	516	512	515	516	510	507	508	503	503	508
55	514	516	515	518	527	532	530	520	508	507	508	506	503	506	512	518	521	521	529	523	525	527	520	519	520	516	521	521	520	516	518	508	506	499	498	506
50			518	515	528	537	536	537	522	514	518	515	514	512	523	514	524	524	531	526	531	533	533	533	532	525	529	531	528	514	520	518	511	510	510	
45					527	540	542	542	531	528	530	515	527	523	524	528	535	540	532	535	542	546	549	548	548	539	540	544	543	527	528	527	525			
40						544	544	547	545	538	539	534	527	536	542	544	539	543	535	539	547	551	555	556	560	555	551	556	553	538	529	538	532			
35						544	548	559	555	554	559	552	546	544	550	555	552	549	550	552	550	552	556	558	563	563	562	566	560	555	546	552				
30							549	569	564	563	563	562	561	561	559	561	559	559	562	565	559	562	566	569	569										
25							560	576	574	573	568	569	573	572	568	570	569	572	571	571	566	570	571	576											
20							571	580	579	580	580	579	578	579	574	573	573					573													
15												581	582	582	578	578																			

EXTREME VALUES OF 500-MB CONTOURS.1951-66
JUNE

LATITUDE DEGREES NORTH — LONGITUDE: DEGREES WEST / DEGREES EAST

MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES

LAT	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
90																		569																		
85									569									569									569									578
80		577		574		570		574		574		573		568		567		571		569		568		574		574		571		570		569		568		571
75		573		572		573		580		581		575		575		575		581		576		575		580		577		574		570		572		573		576
70		580		573		574		579		580		576		581		576		589		587		577		577		574		577		575		581		578		574
65	587	592	587	580	579	580	580	576	578	579	576	574	576	584	584	582	582	586	589	589	586	584	580	582	581	580	578	578	581	581	580	578	576	577	583	584
60	590	595	588	586	583	586	585	583	584	586	582	586	587	585	589	589	586	583	584	584	589	585	586	584	587	585	579	581	580	586	579	578	578	579	586	592
55	588	593	589	591	584	584	585	585	585	585	585	584	586	590	594	596	594	589	590	582	583	586	586	586	589	584	582	584	585	586	581	577	577	577	587	589
50			589	594	589	588	588	587	590	593	586	587	589	588	592	593	590	593	591	589	587	586	586	589	585	583	585	588	587	585	581	580	577	581	586	
45					592	594	593	593	594	597	591	592	594	594	595	593	592	592	591	592	591	585	589	591	585	587	590	592	587	586	585	581	581					
40						597	598	595	597	596	594	597	597	596	598	595	594	595	591	592	588	588	590	589	590	590	592	593	589	588	585	589	589					
35						598	600	597	599	601	596	600	601	601	597	597	597	598	596	594	594	594	593	591	591	593	593	594	593	591	591	593						
30							598	597	597	597	601	602	601	601	599	598	599	601	599	596	596	597	594	596	593												
25							597	597	595	595	598	598	598	601	602	601	601	602	602	598	598	598	594	598													
20							597	595	596	595	595	595	598	600	602	602	602					597															
15												596	599	599	601	601																					

MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES

LAT	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
90																		511																		
85									509									511									508									514
80		522		512		500		500		508		512		515		519		518		516		511		514		511		507		511		515		513		514
75		518		521		512		508		508		515		521		521		516		516		515		512		516		511		512		516		517		515
70		521		521		523		517		512		520		526		524		516		520		520		512		512		516		516		523		524		525
65	517	526	533	534	536	532	524	515	511	512	511	518	519	521	523	516	517	519	526	527	520	522	524	524	518	516	520	516	516	518	522	520	524	524	524	523
60	516	525	528	534	540	539	532	525	519	517	515	520	522	523	521	520	516	524	532	532	531	522	526	521	524	526	527	528	529	531	528	531	524	528	523	522
55	510	519	523	531	537	543	544	536	526	522	518	524	523	521	529	523	528	527	535	541	539	537	525	531	531	531	542	536	535	531	528	521	527	530	520	514
50			525	532	542	543	546	538	540	538	523	512	524	531	534	534	534	537	535	545	546	546	540	535	544	547	547	545	543	539	531	528	530	529	528	
45					540	547	552	557	550	548	538	532	540	535	535	529	542	542	542	549	551	551	555	550	546	560	561	560	550	546	537	538	539					
40						550	561	556	552	553	548	548	554	554	547	549	546	554	549	552	553	560	563	560	562	563	566	566	561	546	549	552	547					
35						558	569	568	556	560	555	556	562	563	555	554	560	556	564	566	565	568	571	571	566	572	570	573	568	560	555	560						
30							575	578	577	575	565	570	570	575	566	560	569	570	574	572	570	576	579	575	575												
25							578	582	581	579	577	578	576	580	574	573	577	578	582	581	576	581	580	577													
20							578	582	582	580	583	582	582	582	579	580	581					580															
15												583	583	583	583	582																					

EXTREME VALUES OF 500-MB CONTOURS.1951-66
JULY

LATITUDE DEGREES NORTH	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
	LONGITUDE DEGREES WEST																		LONGITUDE DEGREES EAST																	
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		566																		
85									572									574								584										579
80		573		570		574		579		576		573		570		575		574		584		579		582		583		580		578		576		573		572
75		574		572		575		572		574		573		575		577		576		587		581		579		582		583		578		577		577		576
70		581		582		579		577		578		576		577		577		581		584		585		582		590		582		582		581		581		576
65	584	587	586	584	584	581	585	584	580	582	582	581	580	576	578	580	583	589	590	589	586	585	587	584	588	587	583	581	583	583	582	581	583	585	583	581
60	586	587	587	590	588	582	586	589	586	583	582	582	584	586	586	582	588	590	590	588	589	587	589	590	586	587	583	581	584	585	581	579	584	589	586	583
55	588	593	592	593	592	589	587	593	592	583	579	587	594	598	593	589	590	593	592	586	588	588	588	589	589	586	581	581	584	585	585	584	587	589	592	591
50			598	596	594	592	593	595	594	589	586	593	600	600	593	597	591	593	595	591	587	586	586	592	592	587	584	584	584	585	589	587	589	589	593		
45					597	596	597	597	594	594	592	595	598	597	597	596	595	595	598	591	589	588	591	593	589	587	586	588	589	591	592	595	594					
40						599	598	599	598	596	596	598	599	601	597	597	598	597	595	593	590	593	594	593	590	592	591	592	592	593	596	597	598					
35						596	600	598	598	598	597	601	598	599	598	601	599	600	598	594	593	595	596	593	593	595	594	594	596	596	596	597						
30							598	597	596	597	598	598	601	601	600	601	601	602	601	600	595	597	597	595	594												
25							598	595	597	596	597	598	600	602	602	602	604	603	599	600	598	597	594	595													
20							598	596	595	595	595	598	601	602	602	602	603					598															
15												597	600	602	602	603																					
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		514																		
85									512									522								519										512
80		516		512		516		515		519		522		523		525		526		523		521		524		518		514		519		519		520		520
75		516		523		520		522		518		521		528		523		523		522		526		523		523		522		524		522		523		522
70		530		534		528		523		524		526		528		527		526		525		531		526		528		534		535		522		529		530
65	529	533	539	543	540	543	538	527	515	512	520	523	525	528	523	531	527	528	529	534	533	534	536	534	535	538	536	535	536	540	536	527	536	537	532	532
60	534	531	537	546	546	550	539	538	526	523	528	530	520	528	531	531	524	524	534	536	536	532	541	538	539	540	540	544	542	540	542	524	535	540	539	537
55	536	534	541	544	547	552	550	548	540	534	528	532	535	538	527	532	535	536	537	532	546	542	543	544	542	544	549	548	547	547	544	546	539	536	540	536
50			533	543	546	544	554	560	547	539	539	540	543	546	539	544	539	546	547	547	551	552	551	548	548	550	553	553	551	539	546	546	543	536	540		
45					553	558	565	568	560	557	551	547	554	559	560	557	554	556	558	556	555	556	559	555	559	560	560	561	559	555	555	555	548					
40						568	575	577	571	568	566	563	569	565	562	558	568	569	566	565	560	557	564	562	568	568	568	570	560	559	558	555	554					
35						577	583	582	579	571	576	577	575	576	570	574	574	578	575	570	568	565	574	573	570	573	574	574	574	568	564	562						
30							582	583	582	582	582	581	581	579	577	579	580	585	583	579	572	579	578	576	572												
25							582	584	582	585	584	586	584	582	579	581	583	583	583	576	571	581	580	577													
20							583	583	583	581	583	586	582	582	582	583	582					579															
15												585	585	583	583	582																					

EXTREME VALUES OF 500-MB CONTOURS. 1951-66
AUGUST

LATITUDE DEGREES NORTH	170 W	160 W	150 W	140 W	130 W	120 W	110 W	100 W	90 W	80 W	70 W	60 W	50 W	40 W	30 W	20 W	10 W	0	10 E	20 E	30 E	40 E	50 E	60 E	70 E	80 E	90 E	100 E	110 E	120 E	130 E	140 E	150 E	160 E	170 E	180
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		574																		
85									574									575								570										572
80		573		573		573		576		576		576		573		572		578		580		575		571		572		570		571		577		580		576
75		573		576		576		579		577		581		575		574		578		582		576		574		577		576		577		578		582		582
70		574		577		581		580		577		581		581		576		581		584		582		581		580		581		576		582		576		582
65	578	579	582	585	585	582	584	585	580	577	577	578	581	582	581	581	579	584	585	586	588	585	585	589	585	581	579	578	579	581	583	581	578	578	583	582
60	586	591	593	592	589	586	582	581	577	575	571	575	577	578	580	581	582	587	586	586	589	586	587	589	586	579	578	579	586	586	585	580	582	584	589	583
55	593	596	598	595	594	590	586	588	583	579	577	581	581	584	588	587	590	590	588	588	589	588	589	592	587	584	584	584	588	584	582	583	585	586	590	590
50			601	597	596	593	594	589	588	589	586	584	589	594	596	597	597	597	594	592	588	590	591	590	588	585	586	589	589	588	588	589	588	589	589	
45					594	596	600	596	594	594	592	593	596	598	599	598	597	594	594	592	592	593	591	590	590	587	592	593	590	593	592	593	596				
40						598	599	598	597	596	595	597	597	600	602	599	598	597	597	596	592	590	593	589	588	592	593	594	593	594	594	595	598				
35						598	599	598	598	599	597	598	600	602	602	600	597	601	597	594	593	596	594	593	593	598	594	596	594	596	597	597						
30							597	597	597	597	597	598	601	601	600	602	601	602	600	597	599	596	595	594	594												
25							597	595	597	595	598	597	600	601	600	599	601	601	600	598	597	598	598	594													
20							594	594	595	595	596	597	598	599	598	598	600					597															
15												596	598	598	598	598																					
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		512																		
85									511									519								520										499
80		514		516		517		508		520		521		524		522		516		519		520		519		512		513		518		518		514		508
75		522		519		512		514		516		520		522		526		525		519		522		522		516		507		517		512		514		518
70		523		531		523		524		516		515		520		525		524		528		523		519		521		516		520		527		524		519
65	526	530	535	539	539	536	530	532	529	524	523	523	523	528	524	523	523	516	522	530	531	532	531	526	520	530	522	531	531	531	530	532	536	529	526	522
60	526	532	532	539	538	544	541	539	534	525	528	525	529	526	523	523	526	527	531	530	527	530	531	535	533	533	532	538	538	540	540	536	534	537	532	524
55	528	526	536	540	544	547	547	543	542	536	531	528	532	534	531	530	529	528	538	540	536	533	533	539	532	539	545	546	545	539	546	545	536	539	531	527
50			538	547	553	544	552	549	552	543	532	532	532	541	533	539	539	538	545	549	549	541	546	539	544	544	552	551	548	546	546	546	546	542	535	
45					554	551	561	556	560	549	540	550	550	554	547	550	552	552	558	555	556	556	563	554	560	560	558	562	557	557	551	552	551				
40						563	574	568	572	565	567	560	565	569	566	564	566	560	563	564	562	566	567	568	569	571	570	570	568	567	560	562	552				
35						572	581	580	579	576	576	574	579	576	575	574	566	577	573	572	574	576	575	573	574	575	572	574	573	571	571	567						
30							583	583	581	580	576	575	582	577	579	578	576	584	583	580	579	581	579	578	573												
25							585	581	583	584	580	576	584	579	582	581	583	585	585	582	582	583	580	579													
20							583	580	582	583	583	576	585	583	584	582	583					582															
15												582	584	585	584	579																					

EXTREME VALUES OF 500-MB CONTOURS. 1951-66
SEPTEMBER

LATITUDE DEGREES NORTH	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
	LONGITUDE DEGREES WEST																		LONGITUDE DEGREES EAST																	
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		561																		
85									560									562								563										565
80		566		571		570		561		559		561		559		559		564		562		564		563		565		569		568		566		568		566
75		575		576		571		564		561		565		566		563		562		569		569		565		566		568		567		572		567		563
70		574		578		576		572		565		575		571		572		574		580		577		570		566		576		577		573		568		570
65	581	573	588	576	573	576	582	576	572	573	572	575	579	579	575	580	582	584	587	589	584	580	579	577	573	572	579	578	578	577	577	575	573	572	574	577
60	585	582	582	583	582	579	582	581	576	573	573	572	577	581	582	583	583	588	587	586	583	586	586	583	578	577	581	581	574	573	573	576	575	573	575	582
55	586	589	588	595	592	585	585	582	579	578	579	580	580	586	590	590	591	595	589	590	583	582	586	585	581	580	578	579	575	577	575	576	578	580	583	585
50			596	598	596	590	589	587	589	585	587	585	585	592	591	593	594	594	593	592	587	588	588	589	583	584	584	582	580	582	580	578	582	586	584	
45					601	595	595	596	594	592	592	593	593	599	597	595	595	592	592	592	589	587	587	589	588	588	589	588	589	584	585	585	588			
40						595	597	599	596	597	594	597	596	601	600	597	597	597	594	589	590	588	590	589	589	589	590	590	590	589	590	592	595			
35						596	597	597	596	598	595	597	599	605	598	598	597	598	596	593	592	592	593	593	593	593	593	594	593	592	594	597				
30							597	595	597	597	597	598	601	598	598	598	598	598	597	597	595	597	596	597	593											
25							597	595	597	595	597	597	598	598	598	598	603	598	598	598	597	597	597	594												
20							594	595	594	594	595	596	598	598	598	598	605					597														
15												594	595	597	597	597																			
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		491																		
85									492									482								487										498
80		510		505		504		492		494		492		501		496		497		497		495		494		491		490		496		504		504		508
75		510		513		506		498		504		494		510		507		506		509		509		505		501		498		499		503		508		506
70		504		515		518		508		508		508		506		507		504		510		510		508		511		506		504		508		514		512
65	508	508	520	526	529	528	520	508	511	504	507	508	512	510	510	510	508	512	519	520	517	510	509	507	512	515	516	503	512	512	514	515	518	519	517	510
60	517	512	521	524	530	529	528	516	512	500	515	520	513	514	512	514	521	519	521	524	518	519	516	515	512	524	525	526	524	523	514	512	515	520	521	516
55	520	510	515	520	528	535	534	516	515	516	523	516	518	514	514	513	522	526	532	529	531	528	529	523	522	528	536	535	533	526	528	520	520	524	525	519
50			518	525	533	543	545	538	532	529	529	520	524	526	526	519	527	536	539	543	538	538	536	539	538	540	546	547	536	536	530	530	530	534	534	
45					544	551	546	548	540	534	536	543	543	540	536	538	536	542	544	551	542	549	550	546	550	556	556	556	547	540	540	541	546			
40						558	558	558	558	552	552	556	555	557	552	558	548	551	556	548	548	559	564	564	567	565	567	560	556	550	547	548	556			
35						559	568	574	569	567	564	564	570	565	570	561	563	568	568	563	566	571	573	571	568	574	571	567	566	556	563	548				
30							575	577	572	571	575	577	577	575	578	572	573	575	578	574	574	577	578	574	569											
25							579	580	577	576	578	575	580	582	582	578	581	582	582	578	578	581	579	575												
20							580	580	579	580	580	569	580	582	582	578	580					581														
15												583	581	579	580	581																			

EXTREME VALUES OF 500-MB CONTOURS.1951-66
OCTOBER

LATITUDE DEGREES NORTH	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
	LONGITUDE DEGREES WEST																		LONGITUDE DEGREES EAST																	
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		598																		
85									546									548								548										545
80		552		550		551		544		541		545		550		558		559		553		557		557		560		558		560		562		559		556
75		564		565		560		545		550		554		555		567		571		563		565		560		564		555		562		570		565		561
70		572		569		566		554		563		559		565		569		578		572		570		564		561		553		557		574		568		564
65	575	578	576	576	577	573	567	563	570	574	569	571	572	571	570	573	577	578	578	580	577	574	570	573	572	565	561	559	557	558	568	569	576	572	576	572
60	573	580	582	578	576	574	571	571	576	581	581	585	582	580	578	577	581	583	584	585	586	578	572	574	572	568	565	561	563	562	563	562	564	573	581	574
55	573	576	584	584	585	583	580	580	584	587	581	583	583	589	586	583	588	586	586	587	586	582	578	578	576	573	572	568	566	567	569	570	573	572	578	578
50			585	593	591	589	588	582	584	584	585	585	590	597	592	588	588	586	586	585	583	581	580	582	578	576	576	575	574	574	574	576	576	580	584	
45					594	595	595	587	586	588	586	588	591	596	594	597	593	588	586	585	585	582	583	585	581	582	582	581	578	578	577	582	585			
40						595	595	590	590	590	591	591	600	602	599	594	593	593	587	588	589	589	585	585	585	586	588	586	584	582	585	587	593			
35						594	593	593	595	594	593	595	600	599	596	594	593	591	589	589	591	592	591	590	589	592	592	589	589	588	591	592				
30							593	594	593	593	595	597	601	596	597	596	596	595	592	593	594	592	593	594	593											
25							593	594	594	593	594	597	598	597	597	596	595	594	594	594	594	594	595	594												
20							593	594	593	593	594	595	597	598	598	596	594					597														
15												594	597	598	597	597																				
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		491																		
85									489									492								491										491
80		490		491		483		488		487		485		489		492		491		490		494		491		484		488		488		485		486		484
75		496		498		483		484		487		490		490		491		492		493		495		493		487		492		494		488		485		486
70		500		504		498		488		486		492		490		490		488		505		498		492		488		491		494		494		487		486
65	501	503	504	508	509	511	510	498	482	482	492	496	494	494	489	492	496	503	510	510	510	499	502	492	494	491	495	498	496	500	497	497	496	496	491	491
60	500	506	503	508	513	519	519	515	504	504	499	496	500	498	503	502	503	506	517	510	514	509	512	500	498	501	502	497	508	503	501	493	492	493	491	498
55	502	502	500	503	516	521	528	523	517	512	503	504	498	507	506	500	512	510	523	524	522	516	513	514	510	510	508	513	520	510	504	504	496	500	499	507
50			500	510	520	525	528	530	513	512	513	512	512	508	520	526	521	522	526	530	524	526	523	522	519	527	528	529	523	515	514	508	511	518	510	
45					524	539	545	540	531	527	524	526	530	525	530	536	532	532	532	536	538	539	526	534	540	546	548	545	538	534	516	519	528			
40						546	543	552	537	535	534	541	547	544	539	548	544	542	534	549	555	548	542	555	558	557	558	554	550	540	535	534	544			
35						548	551	560	547	544	546	558	555	540	552	546	554	556	552	558	560	556	560	563	565	565	564	562	560	556	549	557				
30							560	571	560	563	560	570	560	552	564	561	567	564	564	565	564	565	573	569	570											
25							566	579	571	574	571	574	566	567	571	571	573	572	570	567	569	574	577	573												
20							570	580	579	577	579	577	577	575	576	575	578					580														
15												579	577	576	579	580																				

EXTREME VALUES OF 500-MB CONTOURS. 1951-66
NOVEMBER

LATITUDE	LONGITUDE																																		
DEGREES	DEGREES WEST																		DEGREES EAST																
NORTH	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		547																		
85									564									548									546									554
80		557		549		556		564		566		565		561		554		551		553		557		556		554		556		553		553		556		558
75		558		549		551		555		564		561		561		559		557		562		567		564		558		555		553		550		552		556
70		561		565		547		544		556		562		562		567		566		569		574		566		560		554		553		549		552		561
65	568	571	574	570	563	560	548	547	553	557	560	568	573	566	574	579	578	573	574	578	572	573	572	575	571	565	557	556	557	551	550	551	552	554	562	566
60	574	577	570	565	578	577	562	558	561	561	566	573	577	570	580	584	585	578	579	578	576	576	578	575	572	566	561	556	553	552	554	553	555	559	560	572
55	576	572	572	576	585	584	576	574	578	575	576	576	576	576	582	586	589	582	580	579	580	577	580	581	572	573	572	564	558	557	556	556	561	562	567	564	572
50			582	582	586	589	582	577	582	582	580	583	589	591	589	588	584	582	581	578	579	579	580	578	573	573	570	565	562	564	563	566	568	573	569		
45					594	589	587	581	582	585	584	590	595	595	593	590	587	584	582	580	578	579	581	581	577	577	576	574	572	572	569	570	574				
40						592	588	586	584	585	593	597	595	597	593	590	588	585	583	582	580	583	583	582	581	581	581	583	584	578	576	579	577				
35						593	590	589	588	590	593	595	596	597	595	591	590	590	589	585	585	586	584	583	586	586	588	590	590	588	584	588					
30							592	592	593	594	591	594	594	597	596	592	593	592	589	589	589	589	588	588	590											
25							592	593	595	594	593	594	597	598	595	593	592	598	594	590	592	592	593	593												
20							593	593	594	593	593	594	597	597	595	593	594					593														
15												592	596	598	597	596																				
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		476																		
85									475									481									476									480
80		480		483		478		476		480		483		482		484		488		486		479		474		474		469		470		477		479		479
75		485		484		483		478		484		484		483		488		484		482		478		486		482		478		474		481		482		482
70		493		494		488		478		478		479		488		492		496		483		486		484		479		482		484		480		486		490
65	495	496	498	494	498	501	493	483	486	478	486	487	488	491	488	492	492	502	499	497	490	496	492	488	488	487	483	487	483	480	479	480	483	488	488	495
60	494	491	495	499	507	503	501	494	485	483	483	483	489	493	496	500	504	498	502	504	499	496	495	498	492	491	491	493	493	487	483	482	488	484	484	495
55	495	495	497	500	514	515	512	502	494	492	488	496	500	494	502	502	507	503	510	512	507	505	501	496	504	493	498	502	502	492	493	485	488	491	490	488
50			500	504	512	510	518	514	496	500	499	491	504	510	511	515	512	516	517	519	519	512	511	509	507	516	513	513	509	506	500	498	492	493	495		
45					523	524	522	524	508	502	508	517	525	521	522	518	516	530	528	531	526	522	523	526	525	531	527	528	526	512	508	503	502				
40						534	536	535	524	515	525	524	534	538	536	528	528	530	531	536	536	534	536	539	545	543	543	543	534	525	523	520	520				
35						539	539	543	536	536	548	538	551	541	551	545	540	548	546	550	540	547	548	552	556	554	551	554	546	542	543	538					
30							556	556	553	556	562	558	561	552	555	552	557	556	557	560	555	560	562	564	564											
25							566	570	565	572	569	565	566	561	564	563	568	565	564	569	570	568	571	567												
20							570	578	578	578	574	574	566	570	576	573	573					572														
15												578	575	576	578	578																				

EXTREME VALUES OF 500-MB CONTOURS.1951-66
DECEMBER

LATITUDE	LONGITUDE																																		
DEGREES	DEGREES WEST																		DEGREES EAST																
NORTH	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
MAXIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		547																		
85									549									538									551									558
80		563		558		558		554		546		544		540		543		549		548		552		553		551		553		552		548		556		562
75		570		566		560		553		552		546		548		551		561		558		557		556		557		559		554		555		554		566
70		568		568		555		553		553		549		557		560		558		568		560		561		564		564		560		566		561		559
65	570	570	566	562	558	552	548	553	549	551	547	550	552	559	564	572	572	568	566	572	567	564	565	565	561	569	573	572	566	566	572	572	568	562	564	567
60	577	576	572	570	568	561	555	557	556	552	554	565	569	564	572	575	581	578	572	568	570	567	570	573	568	568	568	570	566	570	568	564	560	562	570	576
55	583	579	577	580	576	578	567	565	560	558	556	568	574	572	578	580	580	576	574	573	569	568	577	578	568	570	564	561	561	564	558	548	547	563	573	581
50			583	588	582	584	577	568	560	562	565	573	579	583	588	585	583	581	582	577	575	573	580	576	571	571	566	567	563	556	550	546	550	564	572	
45					590	588	582	574	570	572	575	580	585	588	591	592	589	586	582	577	576	573	578	581	578	572	572	572	565	562	556	558	567				
40						594	588	579	576	579	582	585	590	591	593	592	589	588	581	582	581	581	578	579	579	579	578	580	573	568	574	570	576				
35						594	590	585	586	587	588	592	594	597	596	593	592	592	585	585	589	585	582	582	585	585	582	582	581	580	585	580				
30							593	591	590	593	593	597	594	598	596	593	592	590	588	589	593	588	586	586	587											
25							594	592	593	594	596	594	594	597	596	593	593	591	590	593	593	589	590	593												
20							593	593	594	594	593	593	597	597	596	593	593					595														
15												593	597	598	598	597																				
MINIMUM VALUES IN GEOPOTENTIAL DECAMETRES																																				
90																		462																		
85									472									471									456									465
80		468		470		474		473		476		475		484		482		479		478		470		462		468		462		454		473		478		475
75		475		481		476		474		473		475		482		479		485		478		482		482		479		478		467		480		480		481
70		482		492		482		477		468		475		482		481		480		488		466		483		479		466		478		483		487		486
65	488	487	490	492	498	492	484	482	472	468	468	475	484	483	479	486	493	490	490	495	490	484	487	488	486	476	482	479	483	479	476	479	483	488	491	492
60	491	491	485	497	499	494	490	490	480	469	480	479	484	488	488	491	495	494	496	492	496	488	492	488	489	485	488	489	486	477	476	482	483	483	491	491
55	495	495	483	495	501	505	502	495	492	482	480	482	484	492	495	495	500	496	502	499	502	494	490	493	492	496	496	500	492	477	470	474	479	484	491	488
50			490	498	505	504	510	510	496	493	490	487	490	500	507	506	505	509	517	507	508	506	508	502	512	511	510	512	504	492	481	478	484	491	495	
45					508	511	524	516	507	504	500	501	511	502	515	515	513	521	524	519	524	522	522	528	524	524	522	515	516	508	496	493	497				
40						524	530	528	518	512	507	521	528	524	530	529	522	530	525	524	529	530	537	537	544	539	539	533	523	520	502	500	507				
35						534	543	540	535	522	536	542	538	539	546	540	538	540	535	533	540	532	543	543	551	546	546	545	540	530	516	520						
30							549	551	550	553	558	558	551	553	553	553	550	548	545	548	552	544	553	553	554											
25							560	565	566	568	570	566	563	563	562	562	560	555	553	555	561	558	562	562												
20							566	575	575	578	578	575	568	569	568	570	566					563														
15												578	574	572	571	574																				

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APPENDIX – SUMMARY OF DATA SOURCES

500-mb contours

Jan. 1951 – Mar. 1957 (03 GMT)	Deutscher Wetterdienst	Daily values
Apr. 1957 – Dec. 1964 (00 GMT)	Deutscher Wetterdienst	Daily values
Jan. 1965 – Dec. 1966 (00 GMT)	Meteorological Office	Daily values
Jan. 1951 – Dec. 1956 (15 GMT)	Japan Meteorological Agency*	Pentad values
Jan. 1957 – Dec. 1964 (12 GMT)	Japan Meteorological Agency*	Pentad values

1000–500-mb thickness

Jan. 1951 – Mar. 1957 (03 GMT)	Deutscher Wetterdienst	Daily values
Apr. 1957 – Dec. 1964 (00 GMT)	Deutscher Wetterdienst	Daily values
Jan. 1965 – Dec. 1966 (00 GMT)	Meteorological Office	Derived daily values

Surface pressure

Jan. 1951 – Dec. 1964 (12 GMT)	United States Weather Bureau Extended Forecast Division	Daily values
Jan. 1965 – Dec. 1966 (00 GMT)	Meteorological Office	Daily values

*Based on United States Weather Bureau *Historical Daily Weather Maps*.

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